NATIONAL BUREAU OF STANDARDS



NBS SPECIAL PUBLICATION 539

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

# Metrology in Industry and Government:

# How to Find Out Who Needs What Services

# NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

**THE NATIONAL MEASUREMENT LABORATORY** provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government Agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities[2] — Radiation Research — Thermodynamics and Molecular Science — Analytical Chemistry — Materials Science.

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Systems and Software — Computer Systems Engineering — Information Technology.

[1]Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington,D.C. 20234.
[2]Some divisions within the center are located at Boulder, Colorado, 80303.

**The National Bureau of Standards was reorganized, effective April 9, 1978.**

# Metrology in Industry and Government: How to Find Out Who Needs What Services

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Dae Jeon, Korea

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OPENING REMARKS

## 0.1. OPENING ADDRESS

Dr. Zae-Quan Kim
Korea Standards Research Institute
Dae Jeon, Korea

It is a great honor to welcome you here to the Korea Standards Research Institute for the Regional Seminar entitled "Metrology in Industry and Government." I would also like to express my sincere appreciation to all of you who made this event possible and meaningful. Today's meeting is especially significant since this is the first of its kind to be held at Daeduk Science Town as well as the first at our Institute.

This gathering earmarks the beginning of the most ambitious project in our recent history of science and technology. The creation of the Daeduk Science Town, with our Institute in its center, is evidence of our Government's long-standing policy toward the modernization of science and technology to support the growing industrialization in heavy and chemical industries. Since metrology standards are the backbone of all industries, this can be taken as a kickoff ceremony of a new era in our science and technology. This is a threshold to achievement of this great economic goal of the country.

We are one of the few institutes which have already moved into this science town. Many others are following us in the next few years. This is the first international seminar held at Daeduk, and many others will be held in the future. The first meeting today is the first in its importance and necessity for our national target of modernization of industry. Because of this, we can attach a special significance to this Regional Seminar.

The geographic location of the Daeduk Science Town is not a simple coincidence; this location is the result of well-considered study so that every part of the country is within a day's travel from the Center. Daeduk Science Town, when it is completed, will be truly the center of Korean science and technology with its numerous research and educational institutions closely tied. This is particularly important for us in establishing an effective national standards system.

K-SRI today, after two years of construction, starts its mission with your blessings and advice. Among all tasks we have, the establishment of a modernized national standards network needs the wisdom and experiences you brought here to share with us. It is very urgent in our country in order to facilitate the ongoing industrialization. Our function is equally demanded for an improved credibility of Korean products in foreign trade with accepted international standards.

Having a seminar with experts from neighboring nations gives us an opportunity to reassert that metrology standards are not limited to

one nation but are a part of an international work that requires continuous cooperation among nations. I hope this seminar will benefit the international community of standards organizations as well as each participating national standards organization.

Once again I thank each of you for your cooperation for this seminar and hope that you will have a worthwhile time in exchange of valuable ideas and productive discussions on the matters of common interest. Lastly, I would like to give credit to the U.S. AID and NBS for their invaluable support that made this Regional Seminar possible.

## 0.2 WELCOME ADDRESS

Minister Gak-Kyu Choi
Ministry of Commerce and Industry
Seoul, Korea

(In his absence due to a rescheduled session of the National Assembly, Minister Choi's paper was read by: Mr. Kwang Duck Lee, Deputy Minister of the Industrial Advancement Administration.)

Distinguished guests, Mr. Walleigh of NBS and Mr. Paupe of AID who sponsored the seminar, and participants from each country represented, it is my pleasure to congratulate you on the occasion of the K-SRI/NBS/AID Regional Seminar entitled "Metrology in Industry and Government" at the Korea Standards Research Institute at Daeduk Science Town in the central part of the country. I welcome all of you, especially representatives from abroad, to this international gathering.

In the last few years, we have achieved great economic growth. Last year we attained the goal for exports of U.S.$10 billion. This remarkable economic success was possible through effective execution of the three five-year economic development plans. Today, Korea as a rising industrial country works toward prosperity and international cooperation.

We have come to a stage in development at which our national resources should be devoted to accelerating development of heavy and chemical industries as a strategy to cope with the ever-changing international economic situations and to keep up the pace of our continuous industrial development.

It is well known that the establishment of a modern national standards system is the foundation for becoming an industrially advanced society. This system is also essential for steady growth in overall economic activities, for upgrading science and technology, for readiness in national defense, and for credibility of our products in international trade.

Measurement standards should be maintained in relation to universally accepted definitions of units and used in daily activities, including production; they should show constancy with time and compatibility irrespective of barriers due to geography, race, or political systems.

Furthermore, the development in measurement standards based on sound scientific principles cannot be separated from the cultural and scientific advancement of our time. It is a very important task for every country to modernize the national standards system which will assume an essential role in building and maintaining a highly civilized society.

For this task, we urgently have to expand the standards organizations in number and quality and to supply sufficient technical manpower. It is equally important that we enlighten the general public as well as those in government and industries to foster a wide-ranging awareness of the importance of the national measurement capabilities.

I believe that the Regional Metrology Seminar which is opening today will serve as a turning point in enhancing the national awareness of the importance of the national standards system.

Since President Park Chung Hee of Korea and the late President Lyndon B. Johnson of the United States in 1965 came to an agreement on a mutual cooperation program in science and technology, friendship between the 2 countries has been demonstrated by active cooperation in science and technology, including metrology, for the last 12 years. Today as you see it, the Korea Standards Research Institute comes into existence as a showcase, the result of joint endeavor. K-SRI will remain as a symbol of our international cooperation and will function as our national primary organization for metrology with significant impact on industrial development and the economy in general.

Our Government will provide the necessary support to make K-SRI a modern standards institute capable of maintaining an international level of competence with expanded facilities to share in innovative research to develop metrology for common benefit.

Our Government will put its priorities into the growth of heavy and chemical industries through emphasis on industries engaged in precision technology. Effective dissemination of advanced measurement technologies, establishment of fair commercial measurement practices, and elevation of productivity of entire industries will also depend on metrology development. So we call on K-SRI and its staff to help in strengthening the international credibility of Korean products and in ensuring the continued growth of the Korean economy.

As some of you may know, the Great King Sejong invented the rain gage in 1441, the first of its kind in the world, which, I understand, was 200 years earlier than that developed in Europe. He also founded a system that is known today as a national measurement system in rainfall. It was intended to scientifically develop agriculture, which was the foundation of the national economy in those days. Today, 537 years later, we are here to discuss the modernization of metrology.

I am convinced that this seminar will become a stepping stone for continuous cooperative works with a significant contribution toward the prosperity and human well-being in all nations.

Finally, I wish you all a successful conference and good luck.

## 0.3 CONGRATULATORY REMARKS

Mr. Robert S. Walleigh
National Bureau of Standards
Washington, DC

I bring you today the greetings and congratulations of the National Bureau of Standards. As we take part in this Regional Seminar in this beautiful countryside and in these impressive new facilities, I am reminded that it was only two years ago that ground breaking took place. I am sure that there is a feeling of great accomplishment among those who played a role in visualizing and creating this new organization, and in bringing it to this point in its development so rapidly.

The Korea Standards Research Institute is now a reality and can begin to establish its place among the standards and measurement laboratories of the world.

It was 77 years ago that the Congress of the United States passed the act creating the National Bureau of Standards. Such a laboratory had been under consideration in the United States for more than 20 years. Much of the demand for such a laboratory came from industry which recognized the need for better standards and improved measurements as our nation began to industrialize in the 1800's. Beginning in the middle of the 19th century, Austria, Russia, Germany, and England had established new national standardizing laboratories, or had reorganized existing agencies, all with the avowed purpose of applying science and scientific methods to their nation's commerce and industry. Most successful had been Germany, working with industry through the great Physikalisch-Technische Reichsanstalt, organized in 1887. In a single decade Germany had achieved world monopoly in the manufacture of aniline dyes and dye products, and her porcelain industry, artificial indigo industry, optical glass, and scientific and precision instrument industries had no peers.

Although a Federal Standards Laboratory had been under discussion for over 20 years in the United States, it still required a burst of nationalism at the end of the 19th century, together with a surging growth of American industry, to combine to assure its serious consideration. When the bill recommending the establishment of the new laboratory came before the Congress, support for it was overwhelming. In personal testimony, letters, resolutions, and editorials, the leading scientists of the country, virtually every scientific agency in the Federal Government and in the states, leading manufacturers and commercial concerns, the railroad and iron and steel industries, manufacturers of electrical apparatus and appliances, and all scientific and technical journals and periodicals endorsed the proposed bill without reservation. Even with all this support, questions were raised during the hearings in Congress as to why such a

new agency was needed. One of the interesting questions had to do with the salary proposed for the Director of the Bureau. It was within $2,000 of the salary of the Secretary of the Treasury, the agency in which the new Bureau was to be located. When questioned about this, Secretary of the Treasury Lyman Gage replied briskly, "Almost anybody will do for the Secretary of the Treasury, but it takes a very high-grade man to be chief of a Bureau like this; this man must have and hold the esteem and confidence of all the scientific men everywhere." Congress approved the bill, although they reduced the number of employees requested from 21 down to a total of 15.

That was the very modest beginning of the National Bureau of Standards 77 years ago. Dr. Samuel Stratton was quickly named to be the Director of the new laboratory, and with the vigor which was characteristic of all that he did, he plunged into his new duties at once. Within a short period of time, he selected a suitable site which, at that time, was considered quite remote from the city. The remote location was chosen to provide freedom from sources of interference, such as noise and vibrations, which might have affected adversely the very precise measurements which would be made in those laboratories.

The site was on a hill six kilometers north of the White House in Washington. Those of you who know Washington today would realize that six kilometers from the White House is practically in downtown Washington, but in 1901, the city of Washington was very small so that the site at that time was quite remote. The site selected was only 30,000 square meters in area.

Dr. Stratton, the new Director, began hiring scientific staff, started a program for the purchase of new laboratory equipment, and began the planning and construction of the new laboratory. It is interesting to read in a history of the National Bureau of Standards that getting the materials to the top of the hill, where the new laboratory was being built, was a very difficult task, and the history speaks of 10- and even 12-horse teams being required to pull some of the materials to the top.

While much of the emphasis in the early days of the Bureau was in the field of electricity, there were many other new and growing areas of work which demanded attention. The pressures for growth were so great that the Director had to be extremely selective in those areas of work which the Bureau undertook so that the effort of the Bureau would be expended in obtaining information which would be most helpful to the nation. Dr. Stratton chose his fields of work well. He had been particularly fortunate in his selection of scientists to work at the Bureau, and as a result, the Bureau's reputation for usefulness and for excellent scientific work grew rapidly. The Bureau also grew steadily in size.

I find some similarities and some contrasts between the creation of the National Bureau of Standards and the creation of the Korea Standards Research Institute. Industrialization came later in Korea than in the United States, but it developed more rapidly in Korea. In fact, the term "industrial revolution" is truly applicable in Korea. With increased industrialization, there was a recognition in Korea, just as there had been earlier in the United States, of the need for more and better standards and for a better measurement basis. In addition, President Park and the Government of Korea established a policy several years ago to support the development of science and technology in Korea. These actions led to a realization of the need for an institute which would be responsible for these standards.

In 1975, the Government of Korea took action to modify its Weights and Measures Law to create a centralized authority with responsibility for the national measurement standards, and it also modified the Special Research Institute Development Law to permit the creation of the Korea Standards Research Institute. K-SRI was officially established in December of that year. Very shortly thereafter, Dr. Kim, Zae-Quan was made president. As in the case of Dr. Stratton at the National Bureau of Standards 77 years earlier, Dr. Kim began hiring his principal assistants and establishing programs for the hiring and training of the scientists and the engineers for the new organization. In contrast with Dr. Stratton, who was limited to only 15 employees at the outset, Dr. Kim expects to have by the end of this year about 200 employees; and he will need all of them and more to meet the needs of the burgeoning science and industry of Korea. As in the case of the National Bureau of Standards, a site was selected for K-SRI which will provide for adequate isolation from sources of interference which might prove deleterious to some of the precise measurements. But whereas the National Bureau of Standards site selected was only 6 kilometers from the White House, the site for K-SRI is 168 kilometers from your Blue House. Whereas NBS started with a mere 30,000 square meters, the K-SRI site is more than 620,000 square meters.

Your foresight in obtaining this larger tract of land will make it much easier for you to expand in the years ahead. Dr. Kim proceeded rapidly with the planning and construction of the new laboratory using the most modern equipment in contrast to the teams of horses used in the early construction of NBS. Dr. Kim also established a program for the acquisition of scientific equipment.

The fact that we are standing in these laboratories today, less than three years after K-SRI was officially established and just two years after ground breaking, is a tribute to President Kim and to his staff, to the people of Korea, and to all of those who have had a part in the programs which have led to this new institution. In extending this tribute, it is well to remember that many influential people in Korea felt strongly the need for such an institution. Their support resulted in an underlying spirit of cooperation from science, industry, and government in Korea, and this spirit greatly assisted in

helping this institution become established rapidly and smoothly. I most certainly include among those deserving thanks at this time your outstanding Board of Trustees under the chairmanship of Park, Sung Chan. I am pleased that the Agency for International Development is a sponsor of this first Regional Seminar. Their very substantial assistance and support for K-SRI has been a major contribution in its creation. Finally, I wish to recognize that the National Bureau of Standards also played a part in helping to establish K-SRI. As some of you may know, NBS has helped several other nations to establish or strengthen their measurement laboratories. This assistance has been a matter of NBS policy. We would urge K-SRI to develop a similar policy in assisting other nations of the region in the improvement of their measurement laboratory services as the need arises.

I say to President Kim and to the staff of K-SRI: You have an excellent foundation. The future is ahead. An institution such as this must establish its own reputation for scientific excellence. That reputation will be established by the quality of the work performed by your scientists. As you know, we at the National Bureau of Standards have had the good fortune of having had a number of your scientists and even some of your administrators working with us in our laboratories in Washington. I am pleased to be able to say that all the reports which have reached me indicated that the quality of those we have worked with is quite high. With such a staff, this new institution should gain a reputation for integrity in science and measurement which will enable it to take its place among the leading measurement laboratories of the world and to grow to be among the great science institutes of the Republic of Korea.

Congratulations and best wishes for the future from the National Bureau of Standards.

And now I would like to present to President Kim, Zae-Quan this plaque from the Director of the National Bureau of Standards congratulating Dr. Kim and his staff on this occasion and looking forward to continued cooperation between our institutions. The text of the plaque follows:

"Regional Seminar

Korea Standards Research Institute
National Bureau of Standards
Agency for International Development

DaeDuk, Korea
September 25-30, 1978

The Director and staff
of the National Bureau of Standards,
Department of Commerce
of the United States of America,
congratulate President Kim, Zae-Quan
and the staff of the Korea Standards Research Institute
on the occasion of this Regional Seminar.
This event represents another milestone
in the history of cooperation between these institutions.
We look forward to a continuing relationship of
friendship, cooperation, and mutual respect."

The plaque is signed "Ernest Ambler, Director, National Bureau of Standards."

## 0.4. OPENING REMARKS

Mr. William E. Paupe
USAID Representative
Seoul, Korea

It is an honor and a privilege to be present at this first regional conference to be hosted by the Korea Standards Research Institute. We believe today's meeting will be the first of many international conferences to be held here in the future. Therefore, this is a very special day for K-SRI.

This site, where we are now meeting, was only a barren field two years ago when the ground breaking ceremonies took place. Today, sophisticated calibration equipment is being installed in K-SRI laboratories. Institute administrators and scientists are already applying themselves to the challenge of establishing a national capability for measurements to provide accuracy in laboratories and industries throughout this country. AID is proud to play a part in assisting this outstanding institute, which will provide the special kind of high-quality technology needed to support the continuation of Korea's dynamic economic growth.

As you all know, international industrial standards are an essential prerequisite to favorable international trade. The enrichment of any nation's technological base also requires in large part the successful adoption and adaption of technological advances developed in other countries. We live in a shrinking world where all progressive nations must have the ability to manufacture quality products according to international standards and to accurately measure the conformance of such products with these standards.

At the international level, all national standards systems have a need to communicate with each other and to maintain liaison with international standardization bodies and overseas laboratories. Dialogues, such as the one that will take place at this Regional Seminar between representatives of specialized research institutes from different nations, will be of mutual benefit to all.

We have much to learn from one another. And, I know of no more attractive or appropriate setting to bring about this learning process. The Republic of Korea blends wonderful ancient traditions with a tremendous zeal for modernization, in pursuing its drive to become one of the leading industrial nations of the world.

Korea is an exciting place to be today. On behalf of the U.S. Agency for International Development, I extend to the organizers and to the participants our warmest and most sincere wishes for an equally exciting and productive seminar.

## 0.5. OPENING REMARKS

Dr. Segundo V. Roxas
National Science Development Board
Manila, Philippines

On behalf of the Government of the Republic of the Philippines and our own Ministry of Science, I wish to extend my greetings to the organizers and participants of this Regional Seminar on Metrology. To the staff of K-SRI and, in particular, to its President, Dr. Kim, Zae-Quan, we extend our congratulations for their pioneering and significant role of establishing an institute that is worthy of emulation by many developing countries such as ours. This institute, as well as the presence of other scientific centers in Korea, speaks eloquently of the recognition, commitment, and the support of the Government of the Republic of Korea to scientific activities in order that science and technology can respond to the needs of its people.

I also wish to express here my personal gratitude for having been invited as an observer to this seminar. For although the thrust of the scientific community in the Philippines is towards the more immediate needs, such as food, housing, medicine, and energy, we are aware and are desirous of achieving a certain degree of sophistication in the field of metrology. For indeed, industrial development and progress is, by any measuring device, a product of improvement in the system and methods of measurement.

This seminar, I am sure, will result in a fruitful exchange of insight and wealth of experience among experts in metrology. The results of this dialogue will be useful to all of us in establishing a certain desirable capability for metrology in our respective countries. Needless to say, a country's capability should be able to supply, at the very least, the present requirements of its industry, the scientific community, and other sectors of its society. It is equally important that those entrusted with the task of establishing the capability of the measuring system be sufficiently gifted and supported to anticipate the immediate and future needs of the country. Depending on the lateral and vertical plans for scientific and industrial growth, the metrology capability should be related and defined in terms of the actual and projected needs.

All nations, including the so-called developed countries, are in a continuous process of development. Interaction between countries, both developed and developing, is now imperative in this modern world. Trading between different countries necessitates the establishment of international measurement standards. It is in this respect that a continuous dialogue, such as we are having now, needs to be undertaken.

The problem of standardization, up to the present point, is far from being completely resolved. This is a long and slow process. It is a tedious and painstaking one, but I am consoled by the thought that scientists, sooner or later, find a commonality and universality in their work to come to an agreement.

I came here to learn by listening from the experts in metrology. What we may learn could be an input to our plans for metrology as it relates to our national goals. In our own quite limited way, we desire to be within the sphere of metrology cooperation, if not at an international level, then perhaps in a regional community. It is for this reason that I value my personal association with the staff of K-SRI, the personnel of NBS, the representatives of U.S. AID and UNDP, and the experts and participants of the various countries present here.

To our Korean host, I wish to make manifest here my sincerest gratitude for the wonderful hospitality accorded me in this lovely country. I wish you a fruitful and most successful deliberation for this seminar.

## SESSION I

## QUANTITATIVE MEASUREMENT IS THE BASIS FOR ALL SCIENCE AND TECHNOLOGY - BUT ARE WE AWARE OF THE NEED FOR METROLOGY?

# I.1. QUANTITATIVE MEASUREMENT, THE BASIS FOR ALL SCIENCE AND TECHNOLOGY

Mr. H. Steffen Peiser
National Bureau of Standards
Washington, DC

Scientific investigation is the exact observation and ordering of phenomena isolated from interfering complexities. The objective of scientific investigation is the comprehension of these phenomena in terms of characteristic principles of universal nature. The philosophy of science holds that these principles cannot be known other than through well-measured observations.

The metrologist--the specialist skilled in making exact observations by quantitative comparisons--has a key role, but measurement alone cannot succeed in the objectives of science. It is by the descriptive interpretation and the consequent ability to predict previously unobserved or inexplicable natural phenomena that science progresses. Success in these insights, therefore, receives the highest level of recognition in the scientific world today.

With ever-increasing accuracy, the metrologist could measure and assemble an infinity of values. The theorist is needed to guide him to critical experiments. Take the example of the parity experiment performed by a team including E. Ambler, the present director of the National Bureau of Standards. That team demonstrated that the quantum mechanical law of conservation of parity does not hold in the beta decay of cobalt-60 nuclei. This result, together with experiments on parity conservation in $\mu$-meson decay at Columbia University, shattered a fundamental concept of nuclear physics, a concept that had been universally accepted for the previous 30 years. The way was cleared for now current physical theories and new, far-reaching discoveries regarding the nature of matter and the universe.

This experiment required measurement of the direction of emission of gamma ray quanta from a radiocobalt source at a temperature within a few thousandths of one degree of absolute zero on the Kelvin scale. It was a triumph for sure, but we must not forget that the crucial suggestion that parity might not be conserved was made by theoreticians T. D. Lee of Columbia University and C. N. Yang of the Institute for Advanced Study, who had previously made a survey of experimental information on the question of parity. They concluded that the evidence then existing neither supported nor refuted parity conservation in the so-called "weak interactions," such as emission of a beta particle or K-meson decay. They also proposed a number of experiments that would provide the necessary evidence for or against parity conservation in weak interactions. They threw out a challenge to metrology, and they received well-deserved credit in the form of a Nobel award.

The sequence of events in the interplay between metrologist and theorist may be reversed.

A metrologist may make a highly accurate measurement and find it does not conform with accepted principles of nature. Such, I think, was the case when T. W. Richards of Harvard, around 1913, stood up and said, "I, with my graduate students, have measured the atomic weights of several leads; I have established their chemical identity; they differ in atomic weight by more than my uncertainty due to possible impurities and other sources of error." However, although Richards was completely convinced of the significance of his results, no theory at that time could account for this metrological observation by one of the finest chemical metrologists of all time. Unfortunately, he did not have the intuition nor did he have the cooperation with a theorist to enable him to propose a theory of isotopes, which was advanced on later independent evidence. Thus, Richards' fine measurement remains almost without impact in the history of science.

My conclusion is that, in science, the metrologist occupies the function which the supercraftsman performed in the trades of former years. He is a key man; without him you cannot succeed in science, but he should not expect to be seen in the limelight of greatest fame, but he can take great satisfaction from the knowledge that his contribution is absolutely essential.

It is no different in technology. I have observed in industry the use of the most exact phase-rule measurements as the basis of the ammonia soda process--certainly one of the technologically most significant developments. I have also observed, in materials research, the fine control of trace phases to develop the high-temperature metals on which jet engines depend. In both these very different fields, you will never hear of the background metrology work, not even if you buy license rights for the Solvay ammonia-soda process or "G18b," the trade name of a high temperature alloy, one of the first to be used by Rolls Royce. However, if anyone thinks one could invent and develop any appreciable new technology without the contributions of a metrologist, he would be mistaken.

Now you may often hear that production can be controlled simply by visual observation instead of quantitative measurements. In any plant in which visual observation actually is the method of control, the efficiency can almost certainly be improved through the use of appropriate measurement techniques. Even in science, there are instances in which the recorded scientific observations were said to differ from theoretic prediction so greatly that a qualitative experiment was adequate to show the discrepancy with theory. For example, Professor Sir Charles Frank, when he made his acceptance speech this year for the first medal of the American Association for Crystal Growth, claimed that the rate of growth of certain crystals from solution differed by a factor of $10^{50}$ from established theory that in the 1930's described growth on an atomically smooth surface.

I did not see the dilemma in this way when I myself became involved in this crystal growth problem in the early 1940's. I was working with Charles Bunn at the ICI Laboratories in Winnington, England. We observed that there was something wrong with the assumptions of the then current theory. The crystal faces were not atomically smooth, so the theory did not apply. Bunn, in search for the really significant variables, showed how to measure the concentration gradient by interferometry right up to a growth face. Only then did we know that it could not be degree of supersaturation or crystallographic orientation that alone determined growth rates. I myself saw a crystal under the interference microscope clumsily broken and two apparently identical fragments grow very unequally under identical conditions. I also saw the growth steps hundreds of times, but to my present embarrassment, the all-important concept of what we now call screw dislocations did not occur to me or to Bunn. It was left to Burton, Cabrera, and Frank to develop their brilliant elaboration of this idea. This became an essential step to modern solidification theories, semiconductor manufacture, and many other developments.

Thus, believe me, in science and technology, inexact observation and qualitative assessments fail to illuminate what is actually happening. They may appear attractive but over and over again they prove to be deceptive. Rigorous control and quantitative measurements near the highest attainable accuracy alone lead to confidence in results and to progress.

Unfortunately, a metrologist has to make another equally important judgment. Often he will find that he cannot be most accurate when he is most precise; nor most precise when he is most accurate. In many real-world problems, precision is frequently more rewarding than accuracy. This situation is most painful to a metrologist because typically his philosophy is to make no compromises in his search for the best attainable accuracy.

I must illustrate my meaning by another example. I choose mass measurements, though I could use almost any other basic unit of measurement. The unit of mass is defined by a platinum-iridium cylinder. Most of what we weigh differs markedly in density from this alloy. Accuracy of mass measurements of objects of normal density demands mass comparisons of standards with different densities. However, comparisons of such objects of the same density can be carried out at much less expense and greater precision. So, suppose you want to weigh at the density of brass or steel, you will obtain more compatible results in less time and at far less cost if you obtain a reference weight at the lower density from the "club" of highly developed standards laboratories rather than to go through a comparison with your national kilogram. Let us even assume that you do that comparison of platinum-iridium to brass perfectly at an accuracy level of 1 in $10^9$, you would deserve to be congratulated for success at a major metrological achievement. Alas, your weighings at the brass density might now be slightly discrepant with those

elsewhere, because it could turn out, as was seriously believed for several very recent years, that all the "club" members might have made a significant error in the mass comparison at different densities.

What I am saying may be shocking to some of my teachers and sound strange to many of my Korean friends. However, my most earnest advice to K-SRI is don't put all your effort in mass measurement into the relationship to your national standard kilogram; don't necessarily develop your own thermodynamic temperature scale; don't do all chemical analyses by absolute measurements of major or trace constituents. In general, do not do too much metrology in terms of the definitions directly but focus on comparisons at or near the highest precision between similar samples, one of which has the desired attribute at a certified value closely comparable with the second sample. If less than the highest precision is needed, do not insist on it but pass the measurement responsibility to others outside K-SRI for the skills of K-SRI are not appropriate. In short, what all our countries need from their national measurement standards bodies is good metrology, compatible internationally, preferably, but not necessarily, highly accurate in terms of the basic definitions. In some cases, the Treaty of the Meter countries may well make changes in the definitions so that they are operationally more conveniently and more accurately realizable.

To Koreans who first visit K-SRI with its impressive facilities and metrological resources, I say make use of this new national treasure. It is a unique facility in Korea; it is an asset rarely found in an industrially young country. When you go home to your own organizations, don't expect your staff to be eager to consult K-SRI staff and to use K-SRI facilities. The tendency may be the opposite. Metrology, as we now know, is at the root of science and technology; so all scientists, engineers, and technologists are by definition amateur metrologists. They may not readily turn to the professionals, although with a little bit of persuasion they will enjoy the interaction and their projects will often benefit greatly. In the past three years, in which I have had the opportunity to work closely with the people of K-SRI, I have become convinced that K-SRI deserves your confidence and trust to be the professional metrological center for Korea, with a self-reliant capability.

## I.2 IMPORTANCE OF NATIONAL CAPABILITY IN METROLOGY FOR INDUSTRIAL DEVELOPMENT--THE INDIAN EXPERIENCE

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In everyday life, man finds it necessary to evaluate quantitatively surrounding objects, phenomena, and processes. The only method of obtaining objective knowledge and information of the material world we live in is measurement. "When you can measure what you are speaking about and express it in numbers," said an outstanding English physicist, William Thomson, Lord Kelvin, "you know something about it; but when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be." Indeed, our knowledge of the physical world we live in depends upon measurement. Equally true, our ability to change the world and through it the living conditions of the people depends largely on measurement. Measurement is thus the nervous system of all our activities in scientific research, in trade and commerce, in defense, in exports, in imports, etc. The concept of measurement more than anything else has been responsible for the tremendous advance man has made from the early hunting civilization to the present-day highly sophisticated industrial civilization. In a sense, the state of measurement science and technology in a country is a true indicator of its technological efficiency and material advancement.

Human life began on this planet a million or more years ago. For most of that time, man lived as a part of nature, finding his food on plains and shelter in hollow trees and caves. His existence was precarious; his numbers small and sparsely disseminated. His mere existence depended upon the availability of plants and animals within a workable distance and his ability to collect and catch them. In these primitive societies, there was hardly any need for measurement.

With the invention of agriculture some 8,000 years ago, settled existence became possible. Trade between small groups was marginal and was carried out through the barter system. However, even then man felt the need to measure--measure the area of his farm, measure agricultural output, etc. Indeed the origin of the science of measurement can be traced to these agricultural societies. Systems of measurement evolved in various countries--India, China, Egypt, Babylonia, etc.--independently of each other.

Until the industrial revolution, the science of measurement was not recognized as an important activity. This was primarily due to the fact that all the products that were available to man prior to the industrial revolution were handmade. It is only in industrial

production, unlike in handicrafts, that each product flowing out of the production line is identical. In handicraft, in contrast, each product is a piece of art and is unique. It is through industrial production that there came into existence the concepts of quality control, quality assurance, etc.

The eighteenth and nineteenth centuries were the most formative centuries for the modern industrial world. It is essentially in this period that the world became one, with the trade between nations increasing several fold. These developments had an impact on measurement science and technology. For the first time, man felt the need to have an international system of units which is followed in all countries, and indeed, such a system of units, now called Le Systeme International, emerged during this period.

This period also represents the time when the world began to be divided into developed, rich, industrial countries and poor, underdeveloped or developing countries. This brought in its wake differential developments in metrology in these two types of countries. In rich, advanced, industrial countries, the science of metrology developed very rapidly both in scope and in accuracy. The concepts of quality control in industrial production, quality assurance, consumer protection, pre-shipment inspection and testing, environmental testing, tropicalization, etc., were developed.

In contrast, in the underdeveloped countries, the science of measurement did not grow as fast, and what is more unfortunate is that the people in these countries did not adequately realize the part played by measurement in industrial production and material advancement. These countries exported their raw materials and imported finished products. The people in these countries hardly realized that by introducing sophisticated testing they could grade their raw materials and thereby earn more. At the same time, they did not realize the need to test imported products, and indeed, there have been instances where lack of testing facilities in underdeveloped countries have been taken advantage of by industrialized countries to dump substandard products. The story of internal trade was not much different. Consumers were cheated by faulty weighing and measurement.

Developments of the twentieth century merely accentuated these trends and disparities. Measurement science became more sophisticated in advanced countries by including in its scope traceability, reliability factors, failure analysis, and characterization of materials for purity and perfection. In terms of accuracy there has been a phenomenal change, and with respect to primary standards, the concept of standards shifted from Newtonian Physics to Quantum Physics. In contrast, the developing countries have not changed much, and even now concepts such as quality control, quality assurance, consumer protection, pre-shipment inspection, etc., play a very marginal role in these countries.

Historically there has been a symbiotic relationship between measurement science, industrial growth, and economic development. Each country has to identify the areas in which it should establish measurement facilities. In other words, the measurement infrastructure must be relevant to the needs of industry, government, and scientific research in that country. By and large in highly developed countries, the needs of industry for measurement are far greater in scope and extension than those of government. In contrast, in underdeveloped and developing countries, the needs of government for metrology are greater than those of industry. This has its parallel in the investment in research and development. In highly industrialized countries, the investment in R&D by industry is much greater than by the government. In contrast, in developing and underdeveloped countries, most of the investment in research and development is by the government.

In India, the measurement system has had its various phases of development, and even today the needs of the government for measurement are far greater than those of industry. India had a highly developed civilization, flourishing trade, and equally developed metrology as early as in the Harappan period, 2300 to 1750 B.C. At that time India had developed standards of length, mass, and time. These developments in measurement techniques were determined by the social and cultural requirements of those days. In addition to the requirements of trade and commerce, Indians in ancient India were interested in designing and building sacrificial altars and in the understanding of the motion of heavenly bodies to predict lunar and solar eclipses, lunar periods, etc. Because of the former, the measurement of length, angle, and area developed. The latter led to the development of measurement of time.

India in the pre-Aryan days was perhaps the first country in the world to enforce officially a system of weights and measures. This civilization has left an extraordinary testimony to the heights to which standardization had been carried out in the fields of town planning, water supply, drainage systems, weights and measures, etc. The principles of legal metrology enshrined in tests such as Arthashastra were very sound and were enforced vigorously and uniformly over a vast region for a long stretch of time. These concepts were further developed during the Maurya period. However, with the decline of the Mauryan empire, the uniformity in weights and measures, the practice of legal metrology, etc., declined and along with them trade and material development. Historically, one is struck by the correlation between trade and material prosperity on the one hand and advancement in measurement science and technology on the other, and both these suffered vicissitudes until the British period.

The growth of the science of metrology in India during the British period was constrained by the needs of the rulers rather than by the demands of economic development. The British rulers were interested in Indian raw materials and in keeping the agricultural economy

fragmented and yet stable. These requirements found expression in the establishment of the Survey of India--both geographical and geophysical--Botanical and Zoological Surveys of India, etc.

During the first world war, when the allied forces in India were cut off from their home countries, they had to make their purchases in India. This led to the establishment of the Indian Stores Department which later evolved into what is now called the National Test House. It is in this period that we find that 150 different types of mass standards and 300 different types of area measures were prevalent. This kept the Indian economy fragmented, and it served the then rulers. Indeed, no concerted effort was made to evolve a unified system of weights and measures.

On attainment of freedom, the Government of India made a very systematic effort to promote the measurement system in the country. The establishment of the National Physical Laboratory in 1947 as the custodian of national standards for physical measurement was an important landmark. Since industry was only slightly developed, the Government decided to establish the metric system of weights and measures. In the introduction of the metric system, the National Physical Laboratory played a major role. In the early phases of development during 1950-1960, the Indian economy was largely based on agriculture, and the Government enacted the Weights and Measures Act and introduced legal metrology. The main emphasis was on measurement of length, mass, and volume.

Since 1960, India has made rapid strides in industrial production. As industrial production picked up, a system of standardization and certification was introduced with the establishment by the Government of the Indian Standards Institute. With economic growth, the Government and the people became conscious of hazards to health posed by fraudulent drugs, environmental pollution, and the indiscriminate use of insecticides and pesticides. This led the Government to establish a chain of laboratories under the Drugs Controller, Plant Protection Adviser, and Environmental Pollution Board. In all these cases, it is again the Government which took the initiative, and most of the testing is done by the Government agencies.

Planners in India are not so much concerned about growth in per capita income as about creating greater employment opportunities for the teeming millions. It is essentially because of this, that the Government gave conscious support and encouragement to small-scale industries, which are more labor intensive, decentralized, and less energy consuming than large-scale industry. These small-scale industries could not afford testing facilities, and again the Government took the initiative of establishing a number of testing laboratories under the Small Scale Industries Commissioners.

With limited resources and an increasing demand for their use for rapid industrialization, the country had to embark on a program more

or less on war footing for export promotion and import substitution. In order to establish credibility of Indian goods in foreign markets, the Government more than the exporter himself was keen to see that only quality products were exported. In order to achieve this, the Government took the initiative of establishing pre-shipment inspection laboratories under the Export Inspection Council. Today we have under this Council a chain of test houses.

During the last decade, the electronics industry has recorded a phenomenal growth. The country started in the early sixties manufacturing some electronic components and assembling some instruments. From this meager beginning, India has reached a stage where it makes sophisticated electronic equipment and systems. Here again, to achieve quality production, a test laboratory has been established in each of the states in the country. These test laboratories are linked with four regional test and evaluation centers which in turn are linked to the National Physical Laboratory. With export of electronic goods picking up, the Government is laying stress on environmental testing, reliability measurement, and failure analysis.

As industrial growth, and with it the economy, picked up, the standard of living of the people and also their expectations have increased. Consumer protection has now become a watchword of the Government in the regulation of trade and commerce. Here again the Government, through a hierarchy of testing laboratories attached to the Directorate of Weights and Measures, is continuously increasing the measurement system infrastructure and activities.

In order to accelerate economic development, the Government made a conscious decision to promote science and technology in the country. Today the country can boast of having a very fine scientific infrastructure covering a wide spectrum. The various agencies, such as the Council of Scientific and Industrial Research, Indian Council of Agricultural Research, Indian Council of Medical Research, Bhabha Atomic Research Center, and the Vikram Sarabhai Space Research Center, are all funded by the Government. With the growth of scientific infrastructure, the needs for measurement have expanded both in scope and in accuracy.

We thus see that, in a typical developing country like India, the Government has to make a conscious and elaborate effort to establish test facilities, enforce measurement standards, and evolve a unified measurement system in which the accuracy of any measurement made can be traced to the accuracy with which national standards are maintained. In India, through Government help and initiative, the test facilities have grown in the various areas as needs arose without any coordination. The Government has been aware of this, and it is now felt that a stage has come when effective coordination should be established for the entire measurement system in the country. This is expected to be done by introducing a system of accreditation of test

laboratories, by categorization of test laboratories as Grade I, Grade II, or Grade III laboratories depending upon their accuracies of measurement, and by calibrating the calibrators. We are now in the process of evolving our National Test and Calibration Service.

In a developing country like India, the Government has necessarily to take the initiative and lend support to the establishment of test laboratories. This is not so in advanced market economy countries where market forces play a major role in economic development, and consequently, the industry has greater needs for measurement. In turn, the needs of the Government in advanced countries for measurement are marginal. The responsibilities of the Governments in developing countries in establishing sound national measurement systems are indeed very great.

# I.3 QUANTITATIVE MEASUREMENT AS A BASIC FRAMEWORK FOR SCIENCE AND TECHNOLOGY

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## A. Introductory Review

If we glance over the history of science and technology, it is apparent that a number of substantial stepping stones necessary for the progress of science and technology have been laid down by the successes of quantitative measurements of various kinds.

Precise observations of heavenly bodies, which Tycho Brahe and Kepler conducted by means of quadrants and other instruments, contributed to the rise of the Copernican view of the universe and of Newtonian mechanics. Without their contributions, we could have neither rational cosmology nor modern space technology.

Galileo's experiments on falling bodies, carried out by the aid of scales, balances, and sandglasses (or blood pulse counting), proved the invalidity of the Aristotelian, metaphysical understanding of the motion of bodies. Without his experimental proof, we could have neither reasonable dynamics nor practicable mechanical engineering.

Faraday's experimental researches on electricity and magnetism, though not aided by mathematical tools, were so quantitative that the results were capable of bringing forth Maxwell's formulation of electromagnetic theory. Without these experimental and mathematical researches, we could have neither the physical theory of electricity and magnetism for the electrical and electronic industry nor modern telecommunication technology.

The law of conservation of energy, conceived by R. Mayer in a rather contemplative way, was consolidated by Joule's patient experiments of high precision and wide variety, which clarified the quantitative interrelations of the mutual conversions among mechanical, thermal, electrical, and chemical energies. Without his quantitative clarification, we could have neither theoretical guideposts nor practical indicators for overcoming the predicted energy crisis on the globe where we live.

## B. The Cradle of Quantum Physics

The most fascinating story of the contribution of precision measurements to the rise of a new scientific idea and subsequent technological developments may be found in the early stage of the history of quantum physics.

At the turn of the centuries, from the nineteenth to the twentieth, precise and systematic measurements of the spectral distribution of the radiant power of blackbody radiators were performed, the results of which drove Planck to create the quantum hypothesis. The three decades after that were crowned with the success of quantum mechanics.

Precise measurement of the radiant power of thermal radiators and the exact realization of blackbody radiators, still difficult in modern laboratories, were achieved at that time by the physicists and technicians at the National Physico-Technical Institute (Physikalisch-Technische Reichsanstalt, founded in 1887 and now called Physikalisch-Technische Bundesanstalt) of Germany.

Now it might be noteworthy that the Institute attacked this difficult problem not only from the academic point of view via the spectroscopic study by Kirchhoff but also from the viewpoint of national needs for the enhancement of high temperature technology, including the efficient production of iron and steel, as well as for improving the economies of illumination by gaslights.

In essence, quantum theory came to the world out of the seeds of spectro-physical interest and out of the needs of industrial utility; it was devised through the intermediary of precise measurement of thermal radiation power and has resulted in the revolutionary evolvement of quantum mechanics, quantum chemistry, quantum optics, quantum electronics, and the widespread quantum device technology.

### C. Methods or Frameworks of Modern Science and Technology

Modern science and technology possess a strong power to influence human society and a remarkable transferability to the various communities of mankind. The power and transferability have been brought about by virtue of the rational way, or the rational "method" of thinking, and experimentation proper to science and technology.

The word "method," which is sometimes dealt with in a much too sophisticated manner in books on the philosophy of science and technology, may be replaced by a less abstract word "framework," and among the various frameworks of scientific research and technological development, I would like to place emphasis on the role of quantitative measurements. This preference of mine can be adequately supported by the above-cited historical facts.

If we look back to the historical examples again, we notice additionally that the framework itself has evolved from a simple and rough one to a complex and precise one. The framework of astronomical observation in the age of Tycho Brahe was constituted only by the measures of angle and time; his instruments were really more than enough for an explorer like Magellan, but most modern navigators have to make use of such a complex and precise tool as Loran C transmissions. The framework of ideas and experiments of Galileo and

Newton expanded to include the kinematic quantities (displacement, velocity, acceleration) and the dynamic quantities (mass, force); the growth of mechanical engineering required the addition of a new framework supporting mechanical work and power. The invention and improvement of steam engines, followed by the rise of thermodynamics, made it necessary to devise further frameworks covering thermal work (heat energy) and power, temperature, entropy, and others. At earlier or later dates, the science and technology related to electrical, optical, and chemical phenomena also required much more complex frameworks for themselves.

## D. Role of the National Institutions in Quantitative Measurement

All of the experiments I have mentioned in the introductory paragraph were carried out either in the academic institutions of royal or local authorities (Tycho Brahe, Kepler, Galileo, Faraday) or in the private workroom (Joule), and their results were expressed in terms of historical, local systems of units of their own era and place. In Galileo's case, the laboratory belonged to the University of Padua of the Venetian Republic; the units of length and mass (weight) were the braccio and the libra. In Joule's papers, we find such units as the calorie, the pound, and the degree Fahrenheit. In the famous book titled "A Treatise on Electricity and Magnetism," Maxwell derived the so-called esu and emu systems of units. (Note: The units cited here are, without exception, not part of the International System of Units (SI) and, therefore, are by no means recommendable for scientific and technological descriptions at the present time!)

On the contrary, the experiment on thermal radiation that I have mentioned in the second paragraph was conducted in a governmental institution founded on the basis of national policy and finance, and the results were expressed in terms of the metric system of units. These facts are highly relevant to the debate about the role of national institutions for research and development of the present day, particularly for those of a quantitative character.

Experiments needed for modern research and development have to be performed on a larger scale than before, with less uncertainty than before, from a more general point of view than before, and in accordance with a more consistent, precise, and solid framework. They are sometimes too difficult to be dealt with solely in private enterprises or by local authorities. Participation of national institutions is very nearly inevitable in most cases.

In fact, quantitative measurements of the highest attainable accuracy (for example, $\pm 4 \times 10^{-9}$ in length measuremnt, $1 \times 10^{-12}$ in time measurement) may be possible only in the national institutions. Even measurements of lower accuracy, which are considered to be performable in other institutions than the national ones, should be controlled to be "traceable" to the national standards.

The age in which we live and work is characterized in many ways: electronics age, computer age, information age, systems engineering age, and so on. Any of these characterizations may be accepted as evidence for the importance of quantitative measurements, which constitute a basic framework for modern scientific research and technological development. In the same context, it may be appropriate to emphasize the role of the national institutions.

## I.4. THE NEED FOR QUANTITATIVE MEASUREMENT IN HONG KONG

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The successful application of science and technology in any country requires not only the provision of an infrastructure of education, training, survey of industrial needs, and research and development institutions together with the associated services, but also the development of a series of activities broadly termed standards. In a technological context, the word "standards" is used in two quite separate but related meanings: first in the sense of measurement standards, i.e., measures of physical quantities such as length, mass, time, etc., and secondly in the sense of specification standards, i.e., published criteria by which a product or a service or a test may be assessed as to quality or performance. Such an assessment usually involves measurement; hence the second category relies on the existence of the first. The orderly development of commerce requires first the establishment of units of measurement and the provision of measures by which working units can be verified. This involves the provision of acceptable standards of mass, length, etc., the necessary laboratory provision for their maintenance, and an organization for their periodic checking and certification. Secondly, the growth of engineering and industrial activities within a country requires the provision of agreed specification standards for quality control and for consumer protection.

In Hong Kong, the requirement to lay down its own specification standards is not urgent, the reason being that local industries are generally manufacturing products to be exported, and hence, they need to follow specification standards of the importing country. In order that these stringent specification standards can be closely adhered to, quantitative measurements of suitable degree of precision are essential. Because of their individual needs and the tendency to move towards a more independent position, manufacturers have been acquiring precision measuring instruments in their private laboratories throughout the years with varying degrees of maintenance and sources of traceability. Some foreign companies and subsidiaries are fortunate to have their instruments traced through their parent companies overseas. This method is undoubtedly costly in many ways, including length of down-time and high risk of damage during transit. More frequently, items used may even have to be duplicated at extra cost. Local companies were less fortunate; with insufficient budget available for maintenance, they cannot afford the high costs involved in transporting their equipment to standardizing laboratories overseas. Thus, all their equipment remained uncalibrated since the times of purchase.

In a similar respect, there are government departments which have definite scientific services to provide to the public and, hence, require precision measurement of input data. For instance, the Royal Observatory, which is in charge of geophysical investigations in Hong Kong, makes precise meteorological measurements of the surface and upper air. When using the information together with similar measurements from other countries, numerical weather prediction models can be advanced and an objective forecast of the weather be made for the public. The Post Office, which has responsibilities under the Telecommunication Ordinance, requires precision electrical measurements to calibrate telecommunication and other electronic equipment. The Education Department requires precision measures in the laboratories of its technical institutes for teaching purposes. Universities and the polytechnics, needless to say, require quantitative measurements for scientific research and development. These requirements, just like those in the private sectors, lead to the acquisition of precision measuring instruments in government departments, laboratories, universities, and the polytechnics.

A survey of the distribution of these instruments has been made recently by the Committee for Scientific Coordination, Hong Kong. This Committee is comprised of leaders of the scientific community in Hong Kong and has the responsibility, among others, to advise the Government on all matters on science and technology. This survey has been published in the Scientific Directory of 1978. From this survey, it is evident that a wide cross section of the Hong Kong industrial organizations, trading companies, scientific institutions, government departments, and utility companies need quantitative measurement as a basis of their activities. The Government has taken note of this survey and, as a first step, has yielded under the pressure of the electronics industry to set up shortly an electronic calibration laboratory covering the range from D.C. to the microwave region.

As a cosmopolitan city, Hong Kong has metric, British Imperial, Chinese, and U.S. customary units all in use. Metrication is proceeding in some sectors where the benefits are clear, and a Metrication Ordinance provides for the replacement of non-metric by metric units. Like many other countries, metrication for the entire community is necessarily a slow and tedious process. The use of Chinese units, in particular, has been so deep-rooted, especially in the foodstuff market, gold market, and sale of Chinese medicine, that Hong Kong, where voluntary changes are preferred, is probably the only place in the world in which Chinese units are still extensively used. A lot of conversion is being done. The need for quantitative measurement is evident to the general consumers for their protection, and this feeling is not confined to industrialists and scientists.

## SESSION II

## MEASUREMENT IS NEEDED TO SELECT RAW MATERIALS, CONTROL PRODUCTION, AND ASSURE QUALITY OF PRODUCTS - BUT IS INDUSTRY AWARE OF ITS DEPENDENCE ON METROLOGY?

## II.1 NATIONAL MEASUREMENT CAPABILITIES FOR INDUSTRIAL DEVELOPMENT IN KOREA

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Presented by: Kwang Duck Lee, Deputy Administrator, Industrial Advancement Administration, Seoul, Korea

### A. Korean Industry in the Past and at Present

During the past 15 years, the Korean economy has grown very rapidly as a result of our Government's strong emphasis on industrial development. Through three five-year economic development plans, the industrial structure has evolved from labor-intensive light industry of the 1960's to technology-oriented heavy and chemical industries.

During this period, per capita GNP has increased to U.S.$870 from $83 in 1961 and a total export to $10 billion in 1977 from $40 million in 1961. It shows astonishing progress for Korea to have attained $10 billion of exports a year, which is similar to that of Japan 10 years ago.

This remarkable economic growth is mainly due to the Government's industrialization policy. The Government proclaimed that the development of export industries is the only way for self-sustenance with our limited available territory and natural resources to support the large population.

The main goal of the first five-year plan (1962-1966) was to strengthen the basic industries. The sectors included in this plan were electric power, textile, cement, and fertilizer. During the second five-year plan period (1967-1971), emphasis was given to increase the export of consumer products. The leading sectors at this time included synthetic fibers, petrochemical products, and electric equipments. The third five-year plan (1972-1976) aimed at an expansion of exports in intermediate and construction materials. Emphasis was placed on the development of heavy and chemical industries. Iron and steel works, machineries, consumer electronic products, and shipbuilding were the main industrial sectors which were strengthened.

During this period, exports have been expanded from the primary products of agriculture, fishery, and mining, through the products of light industries like textile, to the heavy and chemical industries such as iron and steel, machineries, electronic equipments, automobiles, and shipbuilding. There has also been a change in the composition of export goods; in the early 1960's, agriculture, fishery, and mining sectors constituted 60 percent of the total

export, but now the manufacturing sector provides 90 percent of the entire export products.

By the end of the fourth five-year plan (1977-1981), Korea is to export a total of $20 billion a year and to realize per capita GNP of $1,500. The Korean industry in its structure, however, shows weakness in various areas to carry out such a great task. Labor-intensive light industry has its own limitation in growth. It is difficult to expect the light industries to function as a leading force for the economic growth. Hence, it becomes necessary to reorganize the structure of the nation's industry to establish a sound basis for the continuing growth in the economy. The composition ratio of the light industry to the heavy and chemical in 1975 was 55 to 45. As you may remember, Japan had the ratio of 43 to 57 in 1955 when she had a similar size of GNP as that of Korea in 1975.

Among the products of heavy and chemical industries, the following items have been selected as strategic export goods. They are automobiles, electrical equipments, precision machinery, industrial plants and ships from the machinery industry, as well as communication equipments, semiconductor products, and household appliances from the electronics industry.

It is required to meet the goal of this long-term plan. This means that during the period of 1976-1991 the machinery industries must grow rapidly at an average annual rate of 18.7 percent and the electronics industries at an average annual rate of 21.4 percent. Both these industries are expected to be the leading sectors of the Korean industry in the 1980's. It is expected that technology-intensive industries, including airplane, computer, and specialized chemical products, will be possible in the 1980's. Accordingly, in the 1980's we should build an industrial structure capable of supporting precision technology industries and realize a highly industrialized modern society. Science and technology should play an important role in leading the overall economic growth during this period.

## B. National Measurement Capabilities for Industrial Development

### 1. Needs for Modern Measurement Standards

National measurement capabilities ought to form a basis of industrial development in a nation, and precise and accurate measurements serve as a yardstick for the industrialization of the country. Since precision in production technology and accuracy in measurement technology are prerequisite in the heavy and chemical industries, which will occupy a great portion of Korean economy in the 1980's, we must strive for a higher level in precision and accuracy. The current problems we are facing are to establish and maintain the measurement standards system needed in the production of machineries, automobiles, and airplanes and to improve precision and accuracy of measurements.

It is generally true today that most people, from technicians in factories to the top managers in industrial firms, lack understanding of the importance of precision and standards. The National Industrial Research Institute and the Fine Instruments Center are currently providing calibration and inspection services. But calibration facilities are limited in quantity, and trained personnel to handle calibration services are not sufficient to meet the demand.

2. Expansion of Quality Control Campaign

Most small and medium industries had insufficient understanding in quality control practice to improve the quality and to utilize metrology standards for precision measurement. In 1975, IAA started a campaign to introduce a quality control system. Under this program, 160 firms were designated QC leaders in 1975, which increased in number to 2,500 as of August 1978. The number of QC circles in 1975 was 1,300, whereas now we have 31,000. By 1981, the designated QC firms will reach 8,000 in number and 70,000 QC circles. This campaign will be deeply rooted in our industry as a continuous movement of QC.

C. Establishment of National Standards Body: K-SRI

In 1975, the Korean Government established the Korean Standards Research Institute (K-SRI) as a central body of national standards. K-SRI was established 70 to 80 years behind in its foundation to many national standards institutes in the advanced countries, such as the United States, Great Britain, Germany, France, and Japan.

From its inception, K-SRI has received support in advanced measurement technology by the U.S. National Bureau of Standards, a sister institute of K-SRI. Using $5 million of an AID Loan, 500 some items, including the prototypes of primary standards, were obtained in the first phase. Installation of 200 items is currently in progress with a schedule of normal operation by April 1979. Future investments of $8 million from a proposed Asian Development Bank loan and a grant of technical support from West Germany will supplement standards equipments and facilities. With all these, K-SRI will be ready to support the industry in various technical aspects.

The role of K-SRI can be summarized in three major activities as follows:

1. Maintenance and Dissemination of National Standards

The national standards are maintained for the seven base units in the length, mass, time, temperature, electric current, luminosity and mole, and others, including force, pressure, fluid flow, electromagnetics, frequency, acoustics, and radioactivity. The national standards are disseminated through secondary inspection and calibration organizations and the standards reference materials (SRM) for testing, calibration, and analysis will also be provided.

K-SRI, to develop its standards to the international level, maintains ties with international organizations such as the International Bureau of Weights and Measures (BIPM) and many national standards laboratories of the advanced countries. It is also to publish technical reports on measurement and calibration and provide the latest information on measurement technologies.

Also, K-SRI conducts research and development programs to maintain and improve the standards of the seven base units and other derived units to the international level of accuracy.

2. Education of Advanced Measurement Manpower

If we examine the manpower situation of measurements in the sectors of heavy and chemical industries, we find that those who have a college education of any sort are only 7 percent. This educational level of the manpower is quite low compared to that of Japan 11 years ago when she earned $10 billion in exports. At that time in Japan, 35.5 percent of the total population active in measurements received college or higher education. To increase the number in the manpower supply in advanced measurement technologies and to enhance their quality, K-SRI will conduct educational programs. To achieve these objectives, senior members in technical and managerial functions as well as metrology specialists in calibration and inspection organizations and industrial firms are to receive educational training at K-SRI. The short- and long-term training courses in the next 5 years will cover 6,600 persons.

3. Technical Support for Industrial Firms

K-SRI will provide technical support and consultation to industrial firms to solve the problems related to precision measurement. K-SRI will keep a step ahead of the rest of the industries to lead the technical evolution toward an industrialized society in Korea.

D. <u>Establishment of National Calibration System</u>

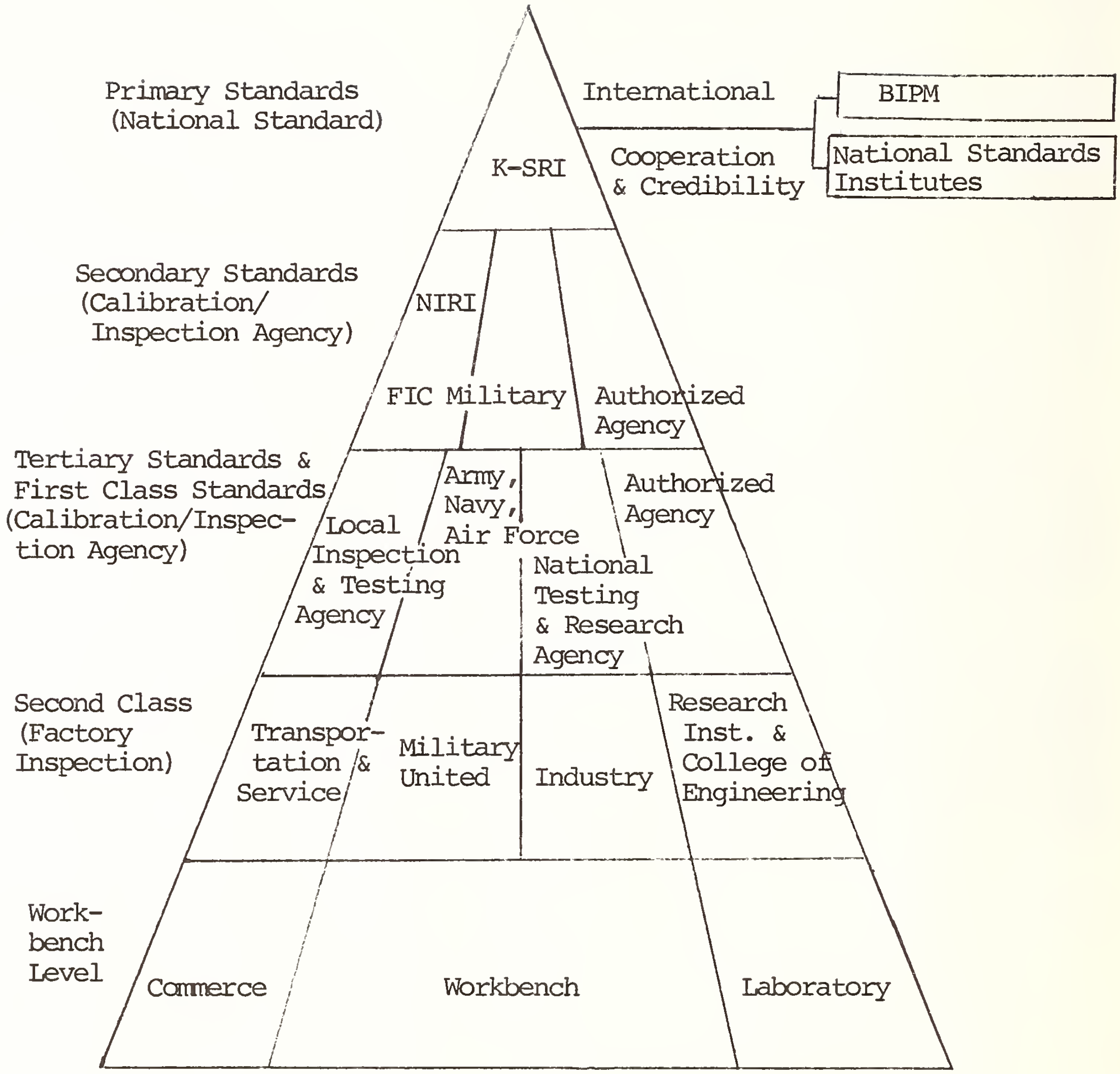
The aim is to improve the national measurement capabilities, but a national standards institute alone cannot achieve this goal. A nationwide dissemination system of standards through secondary calibration and inspection organizations is needed. In Korea, there has been no systematic and nationwide calibration and inspection network available. Accordingly, a systematic calibration network with K-SRI on the top in precision and accuracy is being planned, and the precision level of entire industrial firms will be gradually elevated to the level of advanced countries. As a preparatory step, 19 candidates for the secondary inspection and calibration organizations were selected. This was done through an analysis of the data obtained by the nationwide industrial measurement survey conducted in 1977.

Traceability of standards will be established by representing K-SRI at the top of a conventional national calibration pyramid (see Figure II.1.1). We do so with full realization that, in modern metrological practice, measurement assurance is greatly improved by linking laboratories, including those at different levels, through comparisons of results obtained on the same measurand (sample to be measured). Moreover, for the most critical industrial measurements, K-SRI must reach down directly to the working level. Calibration and inspection services will be given periodically to industrial firms. The geographic consideration of location will be given to provide the optimum services to all industrial complexes, including Seoul, Gumi, Changwon, Woolsan, and the Yeosoo Petroleum Chemistry Compound.

## E. Conclusions

Improvement of national measurement capabilities depends on the ability of a national standards organization, coordination between calibration and inspection agencies and industrial firms, and furthermore, overall awareness of the importance of a national measurement system. Therefore, we should advance an innovative movement for nationwide understanding of the importance of precision and standards.

In conclusion, I emphasize again that industrial development in Korea has played the most important role in leading the fast economic growth. The role of a national standards system is very important for the construction of highly industrialized society with strategic advancement in heavy and chemical industries. It is very meaningful that we discuss the national measurement capabilities in Korea and, in this seminar, find shortcuts for its early realization.




NATIONWIDE CALIBRATION/INSPECTION SYSTEM

Figure II.1.1

# II.2 DEVELOPMENT OF METROLOGY CAPABILITIES IN STEP WITH INDUSTRY NEEDS--A NEW ZEALAND EXPERIENCE

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## A. Introduction

The history of measurement goes back at least 4,000 years in human history. Indeed, it is difficult to see how the ordinary transactions of commerce--the exchange of goods and services--could ever have been carried on if there were not some common agreement to regulate the human tendency for the seller to get less and the buyer to obtain more. The Old Testament of the Bible, which has its origins between the 12th and 2nd centuries B.C., contains at least six texts which relate to the importance of accurate measurements in trade and commerce. For example, in Deuteronomy 25: 13-16, "You shall not have unequal weights in your bag, one heavy, the other light. You shall not have unequal measures in your house, one large, the other small. You shall have true and correct weights, true and correct measures...."

If the need for standards was merely to ensure fair trade practices, however, it would not be necessary to strive for very great accuracy in realizing standards of physical quantities, because the accuracy needed by ordinary trade in the marketplace is such that the accuracy of the primary standard need not be very great--even when one allows for the many stages in descending through the hierarchy of standards from the primary standard to, say, ordinary weighing equipment used in commerce, and for the permissible tolerances at each stage.

It is the requirements of technology, of mass production, and of science, rather than the requirements of ordinary trade, which place great demands on the measurement facilities of a national standards organization. In other words, it is the requirements of advanced industrial societies and of scientific investigation which place the main demands on our measurement capability.

Interchangeable parts used in mass production must be gaged accurately in order to fit together and function as a whole; in designing complex technological systems, the properties of a wide range of physical and chemical quantities must be accurately known, and materials must be selected to meet a wide range of operating conditions, and to make such selections, the engineer depends on accurate data with the characteristic properties of materials.

To ensure that adequate measurement facilities exist to meet the needs of a country, some organizations must have the responsibility for the custody, maintenance, and development of precision measurement

facilities. In various countries of the world, such organizations have been set up, and some of the earliest and best known include the National Bureau of Standards in the United States, the National Physical Laboratory in the United Kingdom, and the Physikalisch-Technische Bundesanstalt in Germany.

Although these national laboratories differ in the detail of their terms of reference, they probably all include among their major responsibilities the following:

1. Development of standards and techniques for consistent measurements.

2. Determination of what measurements are meaningful.

3. Evaluation of measurements and measurement techniques.

4. Determination of major physical constants.

The cost of setting up a laboratory to undertake every kind of measurement to the highest level of attainable accuracy would be prohibitive; and indeed, it is such an expensive exercise that even such a technologically advanced and wealthy country as the United States is having a searching look at just how far it should go in this area of technology. Since limitation of resources--to say nothing of common sense--dictates that we must be selective in determining just how far we should go and in what fields of measurements, we must have a clear policy to guide our developments in this field--and this is particularly true in the less developed countries and in small countries (such as my own).

I believe, therefore, that the general theme of this Seminar is timely in that we are addressing ourselves to a very important problem which I shall paraphrase this way: "What is the 'market' for the measurement services we provide, and how do we match our services to the needs of this 'market' and, therefore, make the best use of valuable scientific resources?"

In this paper I would like to outline our experience in attempting to match the development of our facilities to the needs of industry.

## B. Historical Background

The New Zealand economy has depended, from the days of first colonization by Europeans in 1825 to the present time, on the strength of its agricultural industries. The function of the early manufacturing industries in New Zealand was to supply locally the immediate needs of the small scattered communities for food, clothing, building materials, and home furnishings, and to provide shipping with ropes, spars, and repairs. These handicraft activities grew into factories as the settlements expanded, but it was not until World War II that

manufacturing activity began to develop on any significant scale. It was World War II, and the shortages of imported manufactured goods which changed the manufacturing pattern and gave great encouragement to industrial development. The engineering industries, which contributed so much to War needs, made the greatest progress.

During the 1950's and early 1960's, New Zealand manufacturing industry grew up under various forms of protection designed to shelter fledgling industries until they could become firmly established. From the mid-1960's onward, however, the emphasis has tended to shift away from protection of industry towards the development of internationally competitive export industries, and there has been a very significant rise in the contribution of manufactured industries toward export earnings.

This rise in the importance of manufacturing in the New Zealand scene is really relevant to the need for developing facilities for precision measurement; and it is interesting to note that in our experience the need for precision measurement facilities did not parallel the development of manufacturing industry as such, but paralleled the development of export-oriented manufacturing industries. This thought will be developed further as we go on.

## C. The Development of the Need for Precision Measurement in New Zealand

It is obvious that the precision measurement requirements of a country whose economy is based primarily on agriculture and whose exports are mainly dairy products and wool has a less sophisticated precision measurement requirement than does an industrial country manufacturing such items as jet aircraft, sophisticated electronic equipment, motor cars, and defense equipment. It is not surprising, therefore, that when New Zealand was firmly in the former category prior to World War II, there was little need for precision measurement, and such facilities as we had were relatively unsophisticated. We can, I believe, recognize three phases of the development of New Zealand economy which have had a bearing on the development of our needs in the precision measurement field.

Phase I: Until World War II, New Zealand exported agricultural products and in return purchased consumer goods and such industrial products as it required. As I have indicated in the Historical Introduction, manufacturing industry was, at that time, in its infancy. With the outbreak of World War II in 1939, however, New Zealand was cut off from its traditional supplier--Britain--and there was a need to manufacture in this country goods which had previously been imported and which were now unavailable, and there was also a need to produce munitions to supply military forces. The laboratory of which I was formerly Director--the Physics and Engineering Laboratory--was set up within a few months of the outbreak of War and one of its major tasks was to produce the gages and tooling for

ammunition production and to measure and certify these gages. Another laboratory group (later incorporated into the Physics and Engineering Laboratory) was heavily engaged in the development of radar sets for the armed services, and this development also served to stimulate manufacturing capability in the electronics and telecommunications industry.

Here was a clear case where national need forced the rapid development of precision measurement facilities, and it is remarkable, looking back on those six war years, how much was accomplished in a very short time under the conditions of national emergency.

Phase II: After the War, and because the value of precision measurement facilities had been so clearly demonstrated, it was decided, as a matter of policy, that the precision measurement facilities should be further developed and that the facilities should provide for a much wider range of physical measurements. At the same time, the stimulus which the War had given to manufacturing industries had persuaded the Government that New Zealand needed a much stronger industrial base, and during the 1950's and early 1960's there was a very great development in New Zealand's manufacturing capability. As I said earlier, our manufacturing industries during this post-war era grew up under various protective devices designed to protect fledgling industries until they were capable of withstanding external competition.

It is interesting to note, however, that the development of manufacturing industries did not immediately stimulate the need for precision measurement and testing. Although, by 1956, the percentage of the New Zealand population engaged in manufacturing industry was 24 percent, as compared with 29 percent today (see Figure II.2.1), the demand which early manufacturing industries made on the precision measurement facilities of the Physics and Engineering Laboratory were rather modest compared with the demands they are making today. I believe the reason is that, because these early industries were protected and because they were not subjected to external competition to any great degree, they saw little need to strive for excellence in design, for increasing productivity, for optimum selection of materials, and they did not strive to become internationally competitive while they had a protected and comfortable market at home. During these years, therefore, industry in general made very few demands, relatively speaking, on the precision measurement and testing facilities that were provided by the Physics and Engineering Laboratory. The main demand at that time came not from industry but from such government agencies as:

1. Ministry of Works and Development (for the development of major electric power schemes, geothermal power development, etc.).

2. Transport (the development of civil aviation, precision measurement for the New Zealand airlines, calibrations for the meteorological service, etc.).

3. Defense (precision measurement for the Air Force, Army, and Navy).

4. Science (precision measurements to support the nation's scientific program including research programs in New Zealand's universities).

During this phase the Physics and Engineering Laboratory depended for its reference standards on purchasing precision equipment from overseas and having it calibrated by the great national laboratories in other countries (the National Physical Laboratory in the U.K. and the National Bureau of Standards in the United States), and on using these reference standards to calibrate equipment of lower accuracy. It was only in temperature, where over a limited range of the scale we had the capability of realizing the International Temperature Scale, that national standards were derived from first principles within the country. During the whole of this period, we kept in close touch with the needs of industry and of government departments, and attempted to be just a little in advance of their requirements so that we could meet their needs as they arose.

<u>Phase III</u>: From the mid-1960's on, as was indicated in the Historical Background note, New Zealand, as a matter of policy, has tended to move away from the concept of a protected manufacturing industry to the development of an <u>export-oriented</u> manufacturing industry. This change towards export of manufactured goods is clearly revealed in Figure II.2.2 which shows that, although the percentage of the work force engaged in manufacturing has changed very little, the percentage of manufacturing exports to total exports has increased dramatically.

As our industries have had to become internationally competitive on the world export market, there has been a revolutionary change in their attitude towards the need for testing and precision measurement facilities. The need to compete in export markets in regard to quality, price, and design has meant that they have had to pay great attention to increasing productivity, to the proper use of materials, to the use of more sophisticated production methods, and to the production of more sophisticated products. They have also had to meet the quality and safety assurance requirements of importing countries, and this, too, has made them more test and measurement conscious.

We are still in the third phase of the development of our precision measurement facilities at the present time, and the demands now being made by industry have caused us to change the infrastructure for precision measurement and testing in the following ways:

1. To introduce a testing laboratory accreditation (or registration) scheme which came into formal existence on January 1, 1973.

2. To increase significantly the staffing and sophistication of our national measurement laboratory (the Physics and Engineering Laboratory).

3. To increase the accuracy of our basic measurement standards and to develop the capability of deriving standards of some physical quantities from first principles within New Zealand, instead of relying on high quality reference instruments.

I would like to describe, in general terms, the infrastructure we have now developed and the reasons for it in greater detail.

D. <u>Present Infrastructure of Measurement and Testing in New Zealand</u>

In our national measurement scheme today there are three main elements--the statutory laboratory (Physics and Engineering Laboratory of the Department of Scientific and Industrial Research), the laboratory accreditation body (the Testing Laboratory Registration Council--TELARC), and the TELARC registered laboratories. This infrastructure not only provides the country with the precision measurement facilities that it requires, but it also, incidentally, provides us with the ability to assess accurately the "market" for our precision measurement services.

Before I develop this theme further, I would like to describe two ways in which precision measurement can be disseminated to industry.

Standards of measurement of physical quantities are important because it is on these standards that our national measurement system "SITS"; but if the matter ended with the maintenance of standards of measurements and little else was done about it, it would be a sterile exercise.

One of the most important management responsibilities of a statutory laboratory, in my view, is to see that the facilities and measurement skills, that we develop in maintaining standards, are used for the maximum benefit of science and technology in the country. In fulfilling this responsibility, therefore, a statutory laboratory should provide a calibration service based on the standards it holds. The general form of organization by which this calibration service is provided in a number of developed countries is illustrated in Figure II.2.2 by means of a block diagram.

In this diagram there is one national body which has the responsibility for the custody, maintenance, and development of national standards of measurements, and for the provision of means and

methods of making measurements consistent with those standards. In this diagram we have called the body the "national standards laboratory."

In the field of international standards, the International Bureau of Weights and Measures (BIPM) was created with the principal task of providing uniformity of measurement in science, trade, and industry for the whole world. Thus, through this international organization and with the help of international collaboration, uniformity and improvement of measurement is made possible. In the "international" part of the diagram, international standards are shown by a single block indicating that the standards of measurement in the "national standards laboratory" can be referred to international standards either directly to the BIPM or by comparison between the standards held by various national standards laboratories.

It is customary in many countries for the body which is responsible for "weights and measures" used in common trade to be a separate organization from the "national standards laboratory." The weights and measures organization has the responsibility of administering an Act of Parliament, which provides for the regulation, administration, and control of weights and measures used in commerce and trade. Such an organization employs inspectors to ensure that the provisions of the Act are adequately policed. In the diagram, the weights and measures organization is, therefore, shown as relying on the standards facilities provided by the "national standards laboratory" for the calibration of its highest quality measures.

The "national standards laboratory" can have responsibility for a very wide field of measurement. Local companies, research institutes, universities, and government laboratories can refer to the "national standards laboratory" for the calibration of their highest quality measurement standards. This reliance on the "national standards laboratory" for the calibration of the highest quality instruments is illustrated in the diagram by arrows leading from each type of institution to the "national standards laboratory."

The form of organization illustrated in Figure II.2.2 has the advantage that there is a formal organization which ensures that the national standards are traceable to international standards, and that there is a central body responsible and accountable for the establishment and maintenance of measurement standards and for the provision of a national calibration service. Its disadvantage is that it does not "reach down" to the grass roots of measurement at the industrial level to the extent that is desirable.

As will be known to this audience, the method of linking precision measurement in the "national standards laboratory" to the needs of industry has been tackled very successfully in Australia through the establishment of the National Association of Testing Laboratories (NATA). In New Zealand we have set up a similar organization called

the Testing Laboratory Registration Council (TELARC), and this is the New Zealand equivalent to NATA in Australia. The organizational arrangement in New Zealand is shown in Figure II.2.3. It will be clear from the diagram that, while local companies, research institutes, universities, and government laboratories can go directly to the "national standards laboratory" for calibration of the highest level instrument, they can also, themselves, become approved laboratories for making measurements for other groups providing they meet the registration requirements laid down by TELARC.

E. Laboratory Registration

The purpose of the system is to provide a network of testing laboratories to meet the nation's industrial, commercial, and regulatory needs in respect to:

1. Calibration of equipment and instruments.

2. Evaluation of products.

3. Control of quality and production and certification for compliance with specification.

4. Testing in connection with certification and marking.

Criteria for registration of a laboratory include the following:

1. The person in direct charge of the laboratory and members of the laboratory staff engaged in measurement and testing are suitably qualified for the work in which they are engaged.

2. Laboratory practice, including the supervision of staff, the checking of calculations and results, and the keeping of records, is satisfactory.

3. Laboratory equipment and facilities are adequate for the performance of the testing work concerned and are appropriately housed and maintained.

4. The measuring and testing equipment maintained by the accredited laboratory, together with any auxiliary equipment, has, at a sufficiently recent date, been calibrated in terms of the relevant national standards and found satisfactory (i.e., calibration of all equipment is "traceable" to the national standards).

Registration of a laboratory is given if it meets the above criteria and following a formal assessment. The assessment takes the form of a detailed discussion between the laboratory staff and the assessors, together with an inspection of the premises and laboratory equipment

(including the examination of all calibration information). The assessors normally witness the laboratory staff perform routine testing tasks.

After registration, laboratories are assessed at intervals not exceeding two years, and in addition to formal assessments, the TELARC staff maintain close personal contact between the laboratories' staffs and authorized representatives. Assessors are selected on the basis of recognized knowledge and reputation in a particular area of testing or technology. They must be people of standing within the New Zealand scientific technological communities.

TELARC has defined its broad areas of testing which are intended to encompass all tests undertaken, or likely to be undertaken, in New Zealand. The six areas are:

1. Biological testing.
2. Chemical testing.
3. Electrical testing.
4. Technical testing.
5. Metrology.
6. Physical testing.

For each field of testing, as these broad categories are called, there is a Registration Advisory Committee. The purpose of the committees is to develop technical criteria for each broad field of testing and also to exercise a technical supervisory function over laboratories that seek registration in that field.

At the present time there are 103 registered laboratories under the Laboratory Accreditation Scheme operated by TELARC. Some extracts from the TELARC register of registered laboratories are included in ANNEXES II.2.1 and II.2.2.

F. Advantages of the Laboratory Registration Scheme

I have spent some time describing the laboratory registration scheme for several reasons:

1. The laboratory registration scheme has a beneficial effect on measurement practice (every laboratory was required to improve some facet of its operation before being approved for registration).

2. The laboratory registration scheme ensures that good measurements are carried out in all regions of the country and not just at the national center.

3. One of the primary conditions for registration of a laboratory is that its standards must ultimately be traceable to the national standard, and the feedback of information

between the national laboratory and the registered laboratories in industry throughout the country on measurement needs ensures that the national laboratory is fully aware at all times of those areas of measurement which are of most relevance to the country's needs and of the measurement "growth points" in industry (a laboratory accreditation scheme provides good "market" intelligence as to the needs of industry at any given time).

4. It ensures that New Zealand manufactured goods are thoroughly tested during development, and manufacture and measurement become an integral part of good quality control in industry.

5. TELARC in New Zealand and NATA in Australia have a reciprocal recognition agreement whereby tests carried out by a TELARC registered laboratory in New Zealand are recognized in Australia, and tests by a NATA registered laboratory in Australia are recognized in New Zealand.

## G. Assessing Industry Needs in the Absence of a Laboratory Accreditation Scheme

I have already indicated in the previous section that the laboratory accreditation scheme, because of the feedback between the registered laboratory and the national laboratory on measurement needs in industry, provides very good "market" intelligence to the national laboratory on the type of measurement services it ought to be providing.

This is by no means, however, the only means which we use in order to improve the linkage between industry needs and the national measurement capability. It would be possible (and it is done in some countries) to set up a national measurement laboratory whose only task is to maintain the national standards of physical quantities and to provide a high level calibration service. This arrangement has certain advantages; but one of its principal disadvantages is that the national laboratory can easily find itself divorced from the kind of "market intelligence" it needs to assess industry's measurement needs. It is for this reason that, in New Zealand, we have never contemplated having a separate laboratory for national standards of measurement only, but instead, we have arranged to have the maintenance and custody of national standards as only one of many functions carried out by the Physics and Engineering Laboratory (our national standards laboratory).

The primary standards of physical quantities held by the Physics and Engineering Laboratory are given their legal status through the Scientific and Industrial Research Act 1974, and the primary standards are outside of the TELARC registration scheme (although an integral part of it). We have, however, placed those measurements,

calibrations, and tests which are outside of the primary standards area, within the TELARC laboratory registration scheme.

In effect, therefore, we have within the Physics and Engineering Laboratory a two-tier system:

1. The primary standards which take their authority from the Scientific and Industrial Research Act 1974 and are outside of the laboratory registration scheme.

2. The remaining measurements calibration and tests which come within the laboratory registration scheme.

The advantage of this arrangement is that the industrial calibration and testing program of the Physics and Engineering Laboratory can be an integral part of the TELARC network of registered laboratories; but at the same time the national standards, maintained by the same laboratory, are outside of the TELARC registration scheme and are not subject to assessment and reassessment by TELARC assessors (this must be so since the standards derive their legal authority from Parliament and not from TELARC). The Physics and Engineering Laboratory is, therefore, both the national standards laboratory and a registered laboratory in the laboratory accreditation scheme.

I have described this relationship between the TELARC registration scheme and the national standards held by the Physics and Engineering Laboratory because it emphasizes how much a part of the industrial scene the Physics and Engineering Laboratory is, even though it is the custodian of our national standards. This laboratory works closely with industry in the following areas:

1. It provides a measurement, calibration, and testing service for industry.

2. It supports industrial development in New Zealand through the development and introduction of new technologies suited to New Zealand's requirements and promotion of its effective use in industry.

3. It pursues an advanced program of research in both physics and engineering, in fields chosen for their relevance to New Zealand now or in the future.

4. It maintains specialized advisory services for manufacturing industry.

Because this laboratory is so closely involved with industrial development, it is more able to assess the measurement, calibration, and testing needs of New Zealand industry than it would be if it were not directly involved in industrial development. I believe that this is one of the reasons why New Zealand's standards of measurement have

stayed so closely in tune with the needs of industry and science, and why we have been able to respond so quickly to the increasing demands of industry for increased accuracy by industry as our industries have become more export oriented.

The introduction of the laboratory registration scheme strengthened our links with industry, but the links were already strong before the scheme was introduced.

## H. Conclusion

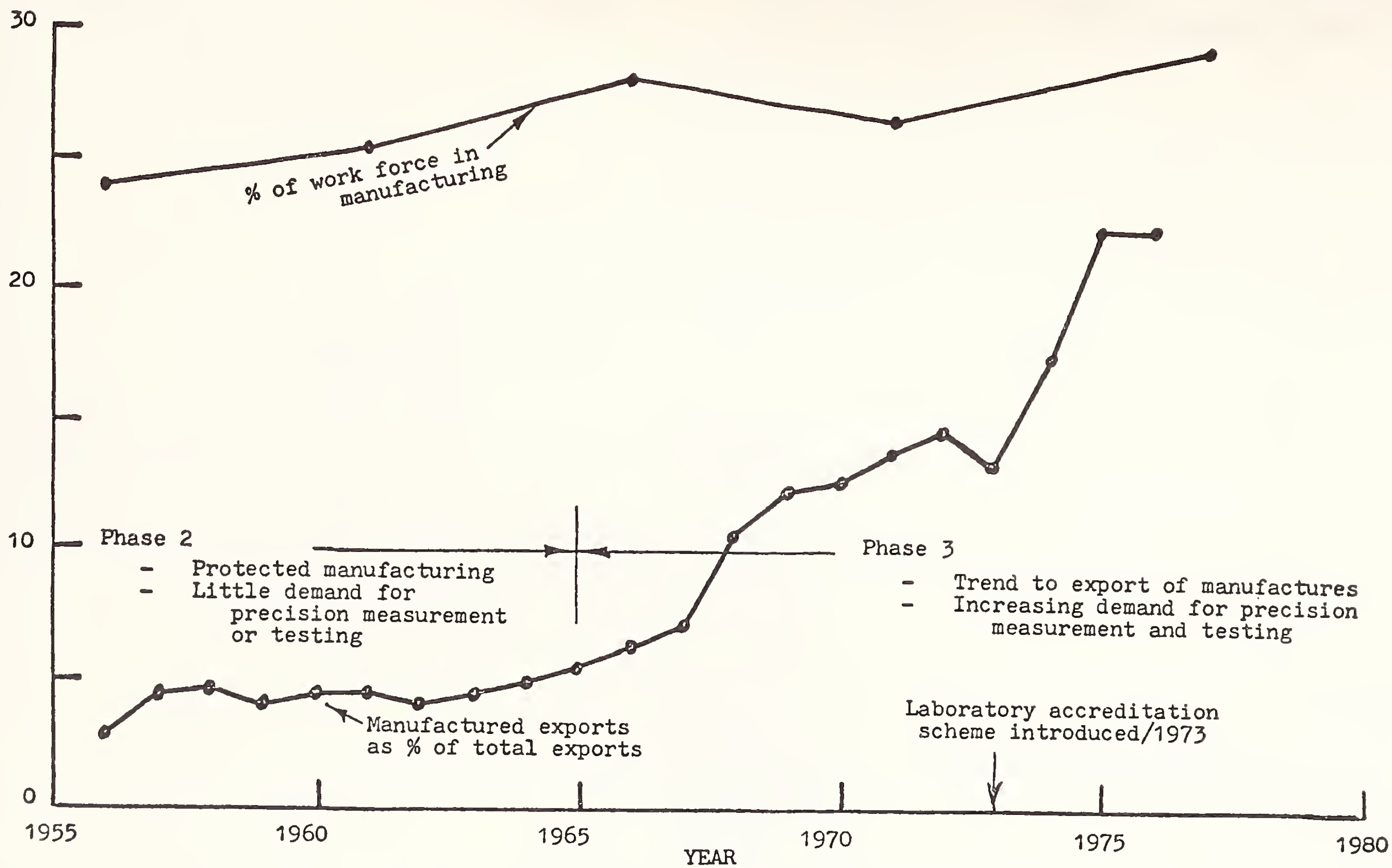
I have tried, in this paper, to show that, in the New Zealand experience, the need to develop a precision measurement capability has depended not so much on the growth of manufacturing industry as such, but on the growth of export-oriented manufacturing industry. It is the challenge presented to manufacturing industry by the need to compete in overseas markets in quality, price, and design which has stimulated industry to realize the importance of good measurement, adequate testing, and good quality control.

In New Zealand we have always had our national standards facilities maintained by a laboratory which has also had strong connections with industrial research and development, and for this reason, our "market intelligence" on industry's measurement needs has always been reasonably good.

In recent years, to meet the needs of industry throughout the country for good measurement and testing practice, we have established a national laboratory accreditation scheme (TELARC); and this too has greatly assisted us to stay abreast of industry's measurement needs.

In my view national measurement standards should, at least in the smaller and less developed countries, be designed to meet the present needs of industry and industry's needs in the medium-term future. As the need for precision measurement by science and industry increases, so too should the capability of the national measurement facilities be increased to meet these needs. In other words, facilities of this kind should be developed on the basis of "need-pull" rather than on the basis of "technology-push."

I hope that our experience in New Zealand has proved to be of some interest to you; but I must stress that each country must develop the system that best meets its special needs. The solutions that suit us may not suit you; but, if there is something in our experience that you find valuable in your situation, we will be pleased to discuss it further with you. A recent paper by J. A. Gilmour, the Director of TELARC, on "Laboratory Accreditation in Australia and New Zealand" may be of special interest, and I would certainly be glad to send you a copy on request.




DEVELOPMENT OF MANUFACTURING AND ITS EFFECT ON MEASUREMENT

FIGURE II.2.1

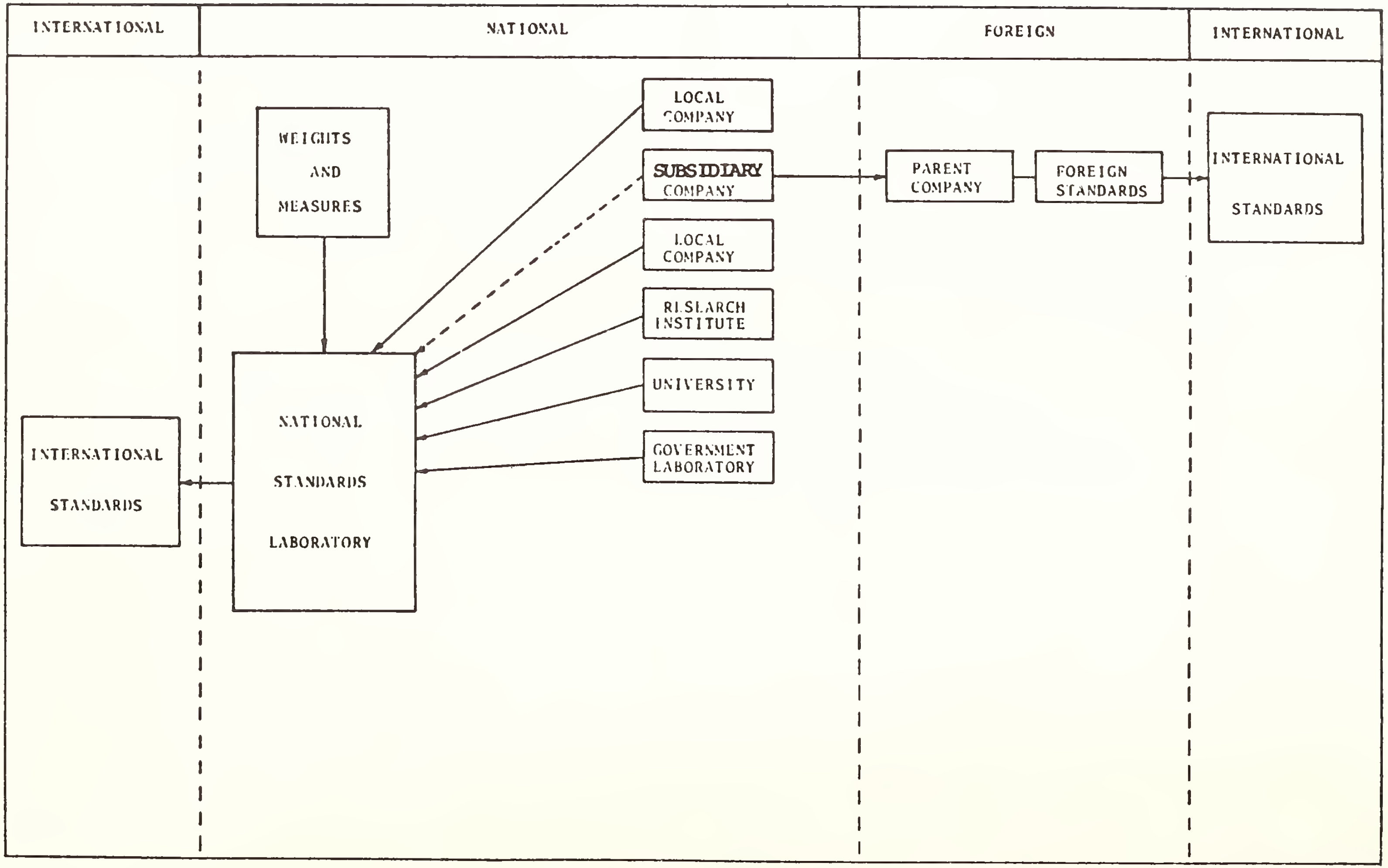



**FIGURE II.2.2**
TYPE OF ORGANIZATION - PRE-TELARC

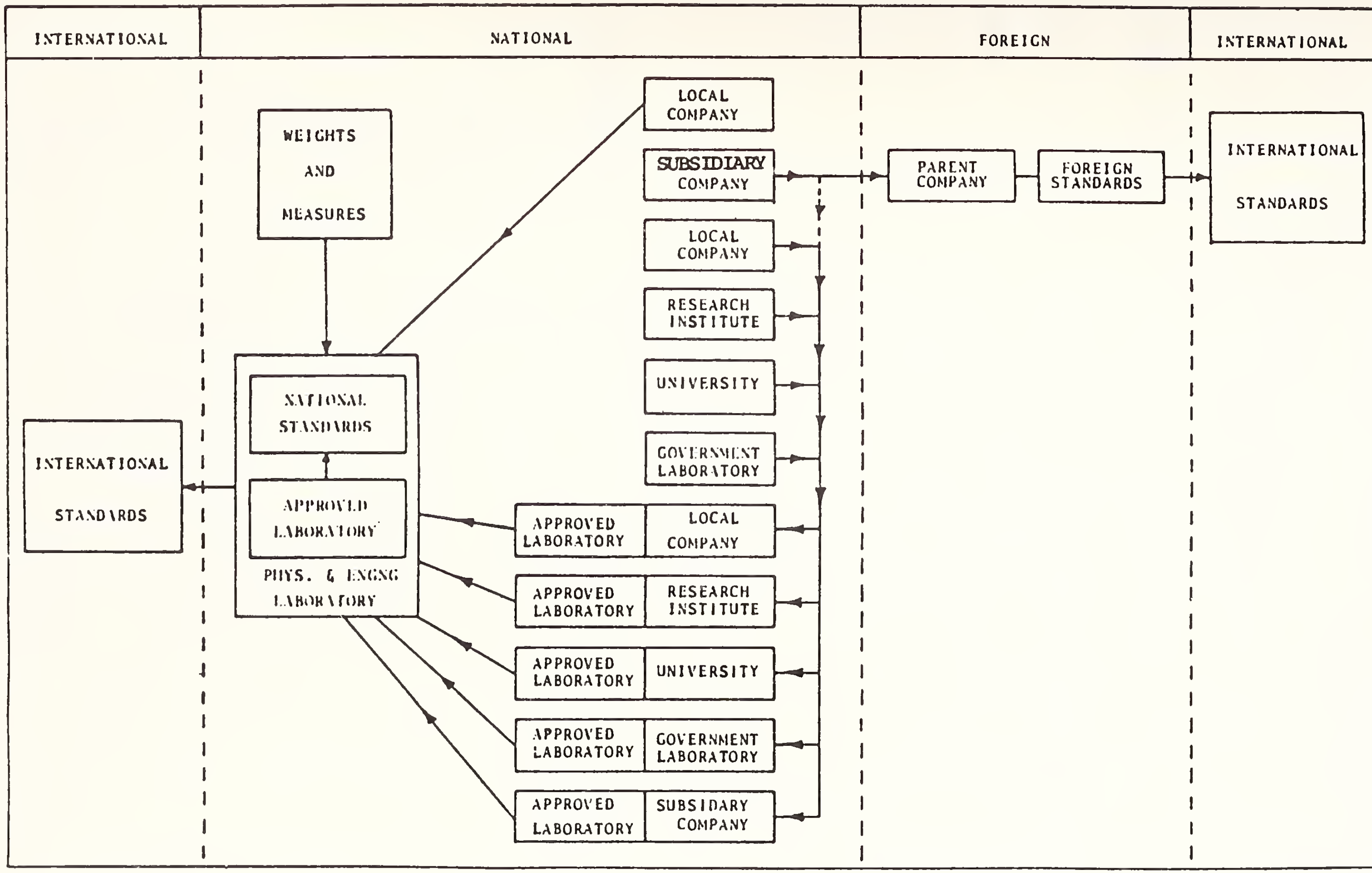



FIGURE II.2.3
TYPE OF ORGANIZATION - POST-TELARC

# Metrology

| | |
|---|---|
| Laboratory | AIR NEW ZEALAND ENGINEERING<br>CHRISTCHURCH BASE<br><br>Christchurch International Airport<br>Christchurch — Phone 588-039 |
| Authorised Representative | L W HOWLAND |
| Registration Number | 33 |
| Availability | 1 |

Classes of Test

5.01 EXAMINATION OF ENGINEERS' LIMIT GAUGES:

(i) Plug, ring and gap gauges

| Type of gauge | Size range mm (in) | Least uncertainty of measurement µm (in) |
|---|---|---|
| Plain plug | up to 50<br>(up to 2) | 1.5<br>(0.000 06) |
| | 50 to 150<br>(2 to 6) | 3<br>(0.000 12) |
| Plain ring | 9 to 50<br>(0.353 to 2) | 10<br>(0.000 4) |
| | 50 to 200<br>(2 to 8) | 15<br>(0.000 6) |
| Gap gauges | 2.5 to 50<br>(0.1 to 2) | 2.5<br>(0.000 1) |
| | 50 to 100<br>(2 to 4) | 5<br>(0.000 2) |
| | 100 to 200<br>(4 to 8) | 10<br>(0.000 4) |
| Taper plug (tapers ≯ 1 in 10) | Taper only | 100µm/m<br>(0.000 1 in/in) |

| Laboratory | AIR NEW ZEALAND ENGINEERING<br>CHRISTCHURCH BASE |
|---|---|

5.03 EXAMINATION OF ENGINEERS' MEASURING TOOLS AND INSTRUMENTS:

| Type of instrument | Size range<br>mm<br>(in) | Least uncertainty of measurement<br>µm<br>(in) |
|---|---|---|
| Dial gauges to BS 907 | up to 50 travel<br>(up to 2) | 2<br>(0.000 08) |
| External micrometers | up to 600<br>(up to 24) | to BS 870 |
| Internal micrometers | up to 900<br>(up to 36) | to BS 959 |
| Vernier calipers | up to 1000<br>(up to 48) | to BS 887 |
| Vernier height gauges | up to 1000<br>(up to 48) | to BS 1643 |
| Straight edges | up to 900<br>(up to 36) | to BS 5204:grade B<br>to BS 818:grade B |
| Feeler gauges | | to BS 957 |
| Depth micrometers | up to 50<br>(up to 2) | 5<br>(0.000 2) |
| | 50 to 100<br>( 2 to 4) | 8<br>(0.000 3) |
| | 100 to 300<br>( 4 to 12) | 10<br>(0.000 4) |

5.07 HARDNESS TESTS ON METAL PRODUCTS:

Vickers tests to BS 427:part 1

# Electrical Testing

| | |
|---|---|
| Laboratory | DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH<br>AUCKLAND INDUSTRIAL DEVELOPMENT DIVISION<br><br>9-11 Albert Street<br>Auckland    Phone 34-116 |
| Authorised Representative | W R BEASLEY |
| Registration Number | 94 |
| Availability | 1 |

Classes of Test

3.00 CONDUCTING MATERIALS:

Ranges and uncertainties of electrical measurements as for 3.01.

3.01 RESISTORS, RESISTANCE BOXES AND POTENTIAL DIVIDERS:

(a) Resistors and resistance boxes

| Resistance | Least uncertainty |
|---|---|
| Up to 10Ω | 5 in $10^4$ or $5 \times 10^{-8}$Ω whichever is the greater |
| 10Ω to $10^6$Ω | 1 in $10^4$ |
| $10^6$Ω to $10^7$Ω | 5 in $10^4$ |
| $10^7$Ω to $10^8$Ω | 5 in $10^3$ |

(b) and
(c) Volt ratio boxes and potential dividers

Up to 1kV    least uncertainty 1 in $10^3$

3.02 INSULATING MATERIALS, INSULATORS AND CABLES:

(a) Insulating materials and insulators

Applied voltages up to 1kV

| Resistance | Least uncertainty |
|---|---|
| Up to $10^{12}$Ω | 5 in $10^2$ |
| $10^{12}$Ω to $10^{14}$Ω | 1 in 10 |

| Laboratory | DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH<br>AUCKLAND INDUSTRIAL DEVELOPMENT DIVISION |
|---|---|

3.03 CAPACITORS:

(a) At frequency of 1.592 kHz

From 1pF to 100μF - least uncertainty 1 in $10^3$

3.05 INDUCTORS AND TRANSFORMERS:

(a) Inductors

i) Self inductors

At frequency of 1.592 kHz
from 1mH to 10H - least uncertainty 1 in $10^3$

3.10 INDICATING AND RECORDING INSTRUMENTS:

(a) Electrical indicating instruments

i) DC Ammeters

| Current | Least uncertainty |
|---|---|
| up to 2A | 5 in $10^4$ or $10^{-8}$A whichever is the greater |
| 2A to 150A | 7 in $10^4$ |

ii) DC Voltmeters

| Voltage | Least uncertainty |
|---|---|
| Up to 16V | 1 in $10^4$ or $10^{-5}$V whichever is the greater |
| 16V to 1kV | 2 in $10^4$ |
| 1kV to 10kV | 1 in $10^3$ |

iii) DC Wattmeters

Ranges and uncertainties as a combination of 3.10 (a) i) and ii)

iv) Ohmeters

Limits as in 3.01 (a)

v) AC Ammeters (at 50Hz)

| Current | Least uncertainty |
|---|---|
| Up to $10^{-4}$A | 1 in $10^2$ or $10^{-6}$A whichever is the greater |
| $10^{-4}$A to 120A | 5 in $10^3$ |

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|---|---|

vi) AC Voltmeters

| Frequency | Voltage | Least Uncertainty |
|---|---|---|
| 50Hz to 400Hz | Up to 1Kv | $1.5 \times 10^{-3}$ or $1.5 \times 10^{-5}$V whichever is the greater |
| 400Hz to 100kHz | 100mV to 1V | 1 in $10^2$ |
| | 1V to 10V | 1 in $10^3$ |
| 100kHz to 1MHz | 1V to 10V | 1 in $10^2$ |

vii) AC Wattmeters (at 50Hz)

Ranges and uncertainties as in 3.10 (a) v) and vi) at unity power factor only.

(b) Galvanometers

Ranges and uncertainties as in 3.10 (a)

(d) Recording instruments

Ranges and uncertainties as in 3.10 (a)

(e) In-situ measurements

Under appropriate circumstances in-situ measurements can be made with the same ranges and uncertainties as for 3.10 (a)

3.11 BRIDGES, POTENTIOMETERS AND TEST SETS:

(a) DC Bridges

By measurement of component parts, ranges and uncertainties as for 3.10 (a)

(b) DC Potentiometers

Ranges and uncertainties as for 3.10 (a) ii)

(g) Attenuators

By DC voltage measurement - Ranges as for 3.10 (a) ii) Least uncertainty 2 in $10^4$ x Ratio

| | |
|---|---|
| Laboratory | DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH<br>AUCKLAND INDUSTRIAL DEVELOPMENT DIVISION |

3.12 FREQUENCY AND TIME MEASURING INSTRUMENTS:

(a) Frequency meters

Up to 500MHz — Least uncertainty 1 in $10^8$ or 0.2Hz whichever is the greater

3.20 CELLS AND BATTERIES:

(a) Standard cells

Least uncertainty of measurement $10^{-5}$V

# Electrical Testing

| | |
|---|---|
| Laboratory | WAKEFIELD LABORATORIES LIMITED<br><br>44 Wakefield Street<br>Auckland — Phone 379-587 |
| Authorised Representative | L O HUNTER |
| Registration Number | 69 |
| Availability | 1 |

Classes of Test

3.80 ELECTRICAL APPLIANCES AND ACCESSORIES:

Testing of electrical appliances and accessories for compliance with the following standard specifications:

New Zealand Standards (NZS)

198, 354, 733, 734, 918, 952, 1055, 1300, 1302, 1303, 1379, 1524, 1525, 1714, 1801, 1825, 1843, 1880, 1910, 1999, 2065, 2147, 2149, 2163, 2164, 2167, 2183, 2207, 2210, 2212, 2221, 2247, 2248, 6301, 6331, MP10.

Australian Standards (AS)

C100, C109, C110, C112, C115, C126, C129, C133, C150, C152, C161, C163, C167, C168, C174, C312, C322, C327, C354, 1660, 3101, 3118, 3125, 3128, 3137, 3149, 3153, 3160, 3162, 3172, 3180, 3181, 3191.

British Standards (BS)

3456

# Mechanical Testing

| | |
|---|---|
| Laboratory | AVERY NEW ZEALAND LIMITED<br><br>212/214 Willis St<br>Wellington     Phone 557 794 |
| Authorised Representative | F R FIELD |
| Registration Number | 14 |
| Availability | 1 |

Classes of Test

| | |
|---|---|
| 4.91 and 4.94 | CALIBRATION OF FORCE DYNAMOMETERS AND TESTING MACHINES:<br><br>Tension and universal machines in tension - grades A & B up to 50 tonf (500 kN)<br><br>Compression and universal machines in compression - grades A & B up to 300 tonf (3MN) |
| 4.99 | CALIBRATION OF OTHER SPECIFIED TESTING EQUIPMENT:<br><br>Vickers hardness machines (direct and indirect calibrations)<br>Rockwell hardness machines (direct and indirect calibrations)<br>Brinell hardness machines (direct and indirect calibrations) |

## ANNEX II.2.2

### SAMPLE PAGE OF TERLAC INDEX
### BY TEST SUBJECT

| TELARC INDEX NUMBER 1 | MAY 1978 |
|---|---|
| **LEATHER** | |
| Waitaki New Zealand Refrigerating Ltd | Chemical |
| **LENGTH AND ANGLE STANDARDS** | |
| Department of Scientific and Industrial Research, Auckland Industrial Development Division | Metrology |
| Department of Scientific and Industrial Research, Physics and Engineering Laboratory | Metrology |
| **LUBRICANTS** | |
| BP New Zealand Ltd | Chemical |
| Ministry of Defence, Defence Scientific Establishment | Chemical |
| **MACHINE TOOLS** | |
| Department of Scientific and Industrial Research, Auckland Industrial Development Division | Metrology |
| Department of Scientific and Industrial Research, Physics and Engineering Laboratory | Metrology |
| **MAGNETIC PARTICLE TESTS** | |
| See Nondestructive tests | |
| **MEASURING TOOLS, ENGINEERS'** | |
| Air New Zealand Christchurch | Metrology |
| Department of Scientific and Industrial Research, Auckland Industrial Development Division | Metrology |
| Department of Scientific and Industrial Research, Physics and Engineering Laboratory | Metrology |
| **MEDICAL DIAGNOSTIC** | |
| Nelsons (NZ) Ltd | Biological |
| Waikato Hospital Pathology Department | Biological |
| **METALLIC COATINGS, CHEMICAL TESTS** | |
| Department of Scientific and Industrial Research, Auckland Industrial Development Division | Chemical |
| **METALLOGRAPHIC TESTS** | |
| Ajax GKN Ltd | Mechanical |
| Department of Scientific and Industrial Research, Auckland Industrial Development Division | Mechanical |
| Materials and Testing Laboratories Ltd | Mechanical |
| Ministry of Transport, Defence Scientific Establishment | Mechanical |
| New Zealand Aluminium Smelters Ltd | Mechanical |

## II.3 IMPLEMENTING METROLOGY FOR DEVELOPING INDUSTRIALIZATION

Mr. Herudi Kartowisastro
Indonesian Institute of Sciences
Bandung, Indonesia

### A. Applied Metrology

This presentation will emphasize not only the role of metrology but also the actions to be taken by metrologists in the future. I am taking this attitude, because it is evident that we, who come from developing countries, cannot simply copy the system existing in most developed countries, which have already a long history of industrialization. On the contrary, in most developing countries, the industrialization process is just starting, and it must be backed up by an infrastructure of science and technology which is generally lacking, including that related to the field of metrology. With this in mind, then, our job is to study in particular the implementation and improvement of the application of metrology in industry.

I have no doubt that most of us, as metrologists, are aware of the essential role of metrology in industrialization, but knowing or waiting passively for a demand to come is not enough. In my opinion, such a passive attitude will have little impact on the industrial development of a country.

In a developing economy, particular efforts in applied metrology are required for any increase in industrialization to ensure all possible improvements in quantity, quality, and variety of the items manufactured. Nowhere can measuring instruments be absent, otherwise the country would remain bound to its existing industrial limitations. Metrology, however, should fit the existing stage of advancement of the country. Neither too much nor too little metrology should be used, thus keeping measurements consistent with the quality and price of the products concerned.

Where industry is still young and occurs in the shape of artisanship rather than a structure for mass production, measuring instruments are mostly intended for commerce. To back up this kind of activity, periodic inspection and calibration are needed. At this initial stage, only secondary standards for basic units are necessary; they can be traceable internationally to standards in other more developed countries or through the instrument manufacturers. This also applies for standard reference materials.

At the second stage, with the growth of industry, instruments will be used extensively, and some will begin to be produced in the country to serve not only commerce but also the growing industry itself. Some of these instruments will soon call for control by public authorities involving the concepts of approved prototypes, intercomparisons,

periodic inspections, and more precise measurements in the production process. National industry will tend to replace foreign industry and gradually to produce its own series of design systems, measuring instruments, and standards.

Taking all this into consideration, I can see clearly why the Republic of Korea has taken serious measures in metrology. We have seen the fast growing industrialization in Korea, and no doubt K-SRI will take part in its further development. Here the relationship between industrial development and metrological activity has a significant impact. The interesting aspects are not from the point of view of the metrologist only, but also include the "political will" provided by the Government of Korea and also the awareness of Korean industry.

Looking at this situation, we Indonesian metrologists have tried to study the matter rationally, making comparative studies with developed and other developing countries. For one thing, we know that we as metrologists should take an active part in raising industrial productivity directly. We should join in the production cycle in such ways as, for example, "in-plant measurements" in the production process. Activities such as these are rarely undertaken by metrologists. However, with this approach, they will be able to see the direct impact of metrology on productivity.

The objective is to stress the fundamental need to control the entire process of production and product testing by monitoring if economically sound products are to be delivered at competitive prices to satisfied customers. It should also become clear that the careful, rational, and controlled application of metrology to all technical efforts is essential, and because metrology is an integral part of research and development, design evaluation, quality control, product certification, product testing, and data feedback for product improvements, this cannot be overemphasized. It is for this reason that government and industrial leaders must recognize the role that measurement plays in the financial health of industry and the economic strength of nations.

The need for controlled measurements* in applied metrology is the thread which ties together product development, product manufacture, process control, and product testing to insure that the item actually delivered is reasonably similar to the prototype that was developed and the item that was promised. "Product development" refers to research, development, testing, and evaluation leading up to the construction or improvement of an item, based on laboratory tests, measurements, breadboard layouts, etc. "Product manufacture" means production design, engineering proof testing, and factory equipment set up to build more than one of an item. "Process control" means the

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*J. L. Hayes, Needs for measurement controls in developing industrialization, pp. 79-84, National Bureau of Standards (U.S. Special Publication 359 (December 1971).

checking of quantity and quality during production processes as they occur, so that proper constituents are being mixed and proper control is maintained on such parameters as temperature, humidity, and feed rate. "Testing" refers to the evaluation of the finished product through inspection and physical measurements to confirm that they conform to desired specifications and satisfy the original design and development objectives.

In such situations, it is essential that a proper relationship exists among research and development measurements, design specifications, production control, and product specifications and tests. This requires proper control of measurement errors during research, the careful writing of testing specifications, the proper selection of measuring equipment and measuring methods, and the assurance that the tolerances set are compatible throughout all the stages of manufacture and use.

We can see here the wide spectrum of activities in which metrology could play a significant part in the field of industrial development, even though in most developing countries this is not yet generally recognized by government and industrial leaders. This situation cannot be allowed to remain, and it is up to the metrologist to secure changes himself.

This situation is also felt in Indonesia, even though the second five-year plan already includes a national program for calibration, instrumentation, and metrology. But work still has to be done to convince government and industrial leaders of the need for metrology within industrial development.

B. <u>Study of Problems</u>

To know the essentials of the use of metrology in industrial development, we have to consider a selection of the problems likely to be encountered in the implementation of applied metrology. To answer this question, first we have to study the role of metrology in industry and discover why metrologists in most developing countries are facing difficulties in penetrating industry and in convincing industrial and government leaders.

I would like to put some suggestions forward on the basis of our experience in Indonesia over the last five years. My observations show that there are only limited relations or areas of cooperation between metrologists and the industries which actually need metrological backing. I have seldom seen action taken by metrologists which had a direct relation to raising productivity. This is one of the reasons that a gap exists between metrologists and industry. I am not saying that the metrological capability is not there; on the contrary, sometimes the capability is quite adequate. Another reason is that most metrologists do not want to think in terms of cost, but

mostly in technical terms only. Once again a common base with industry is lacking.

To mention two countries as examples in which there are already close relations and cooperation between metrologists and industrial leaders, Australia has the National Association of Testing Authorities (NATA) and Russia has 129 Calibration Centers throughout the country.

NATA has shown successfully the way in which measurements can be transmitted from the national standardizing laboratory to industry. This organization runs a voluntary registration scheme for testing laboratories. Briefly, the idea behind the services which NATA provides is that a firm or institution which is capable and willing to undertake calibration work is first examined by assessors chosen for their knowledge of the field to see whether the organization has appropriate equipment, whether it is installed in suitable premises, and whether the operators are experienced in measurement and in reporting the results of measurement. If these and other conditions are fulfilled, then the laboratory will be registered as a NATA approved laboratory in the measurement field in which it has the necessary skills. It has the right to use a standard mark on its test reports, which guarantees to the industrial user of the service that calibrations have been carried out by a laboratory which has been judged to be competent in this particular field.

The system has a number of very significant advantages. First of all, the standards on which the firm or institution relies for its calibrations are checked regularly in such a way that the calibrations can be traced back to the national standards. Australian industry benefits from the improvement which has taken place in laboratory practice and from the better testing which has led to better quality control and higher quality products. NATA-endorsed documents have become a reliable basis for purchasers' acceptance of suppliers' test results. This avoids unnecessary duplication of test work and speeds up acceptance of goods supplied under contract. It also conserves scientific and technical manpower. NATA assessment and reassessment provides management with an independent measure of laboratory performance.

NATA provides a necessary and important link between those who have the responsibility for the custody, maintenance, and development of national standards and those who need to make accurate and reproducible measurements in industry. There are about 750 registered laboratories in Australia, 550 of which are industrial laboratories. In a country the size of Australia, the existence of 550 industrial laboratories of known competence is a tremendous resource of measurement skill.

In Russia we find 5 standards laboratories and 129 Calibration Centers, one of the prime essentials to industrial development. Strong centralized coordination and guidelines complete with

intelligent application of measurement control have shown results in its industrial power.

In these two countries, there are nationally organized efforts in which the national system matches the conditions of the country. I like to use the word "optimizing," which means that we cannot just neglect the historical part of metrology in the country concerned, but must utilize all existing establishments which have certain metrological activities. Thus, the funds and forces of the national metrological capability are mobilized. Another essential part of this approach is that the link to the industry is easier and is geographically more feasible.

In most developing countries, the industrial infrastructure is lacking or weak, including the field of metrology. For this reason, government support is essential, in part because in most cases capital investment in metrology may not itself return a profit in a short term. Convincing government leaders of this situation is not always successful, because in most developing countries, investments are concentrated on quick-yielding projects or programs. Once again, metrologists have another task besides technical matters, i.e., convincing the Government. This has often been neglected and forgotten by metrologists.

We are all aware that as accuracy of measurement is pushed higher, so too are the difficulties and costs of making the measurements. For industrialized countries such as the U.S.A., the function and responsibility of an institution like the National Bureau of Standards (NBS) is to achieve the most reliable standards, measurements, and test procedures possible at a given time, limited only by the state of the art at that time. I am sure that while we all agree that this would be a worthy goal, we must also recognize that in developing countries there is a limit to the resources which can be allocated to this field. No matter how laudable it might be to strive for perfection, it may be necessary in the interest of common sense and optimal utilization of resources to stop short of what can conceivably be achieved. This certainly occurs for a developing country like Indonesia; therefore, we attempt to ensure that our standards are adequate to meet the needs of industry in the country at a given time, but we do not attempt to stretch our measurement capability to the highest limit. But I am not suggesting that there should not be a national standards laboratory; on the contrary, the country should have one, but the level should match the country's needs.

An interesting report was produced by NBS studies, which states that 6 percent of the GNP (1963) is involved in metrological activity directly or indirectly. This is another example of the importance of metrology.

In order to convince the other side, i.e., industry, another approach has to be made. The essence of this is that metrology should show

economic meaning, be a part of the production process, and have a significant role in raising productivity. From this point of view metrologists should go down to the lowest level of metrology, i.e., reaching the "users." The national measurement system concept, introduced by NBS, involves five structural levels: (1) the conceptual system of measurement, (2) the basic technical infrastructure, (3) the realized measurement capabilities, (4) the dissemination and enforcement network, and (5) the end users of measurements. We can see that the last three levels form an important part directly involved in the process of production in industry. A direct approach of rendering metrology services to industry to solve measurement problems it is facing is a practical one which will change the attitude of industry toward the metrologist. Another approach which is convincing is to show the meaning of metrology in terms of cost by improving the process of production. For example, with close cooperation with production engineering experts, it would be quite possible to attain this.

In the last part of this section, I wish to stress the development problem of metrology in Indonesia, which I think has a particular situation that requires also careful attention in the application of metrology. As in other developing countries, the metrological infrastructure is far from adequate, and this has been felt more and more during the last ten years, during which time industrial and agricultural development has shown significant progress.

The primary goal of Indonesian national development is to further promote the well-being of the people as stated in the 1978 Guidelines of the State formulated by the Congress (GBHN). Development should be based on the three principles: equity, economic development, and socio-political stability.

In order to achieve this goal, during the Second Five Year Development Plan (PELITA II), priority was given to the development of the economic sector, utilizing the available natural resources, and an attempt was made to increase human resources participation to the fullest extent to achieve maximum benefits for the people. It was not expected that a balance between agriculture and industry would be achieved before the end of the Second Five Year Development Plan. This is one reason why Indonesia focused its economic and social development programs on agriculture, with support from the industrial sector, and on the industries responsible for the processing of the various raw materials and products to meet consumption needs and earn foreign currency through export.

Four basic problems are pertinent to the development of Indonesia, namely:

1. Population in all its aspects, such as the total number, population growth, human settlement, fulfillment of basic human needs.

2. Utilization of natural resources, whether biological, mineral, or energy resources, and facilities for development.

3. The application of science and technology as a means of achieving national goals, especially for the realization of our economic goals.

4. Socio-cultural aspects which can support or hamper development, such as value systems and trade.

C. Policy for Industrial Development

The target for industrial development during PELITA III will be the conversion of raw materials to semifinished or finished products. The problem of creating more job opportunities for less skilled labor is also taken into account. Around 80 percent of the Indonesian population lives in rural areas; therefore, most of the labor force (75 percent) and also the problem of high unemployment are located in the rural areas.

In this context, the potential of science and technology should be developed, for example, in research and survey capabilities, consultation, etc. In order to select the proper technology for the small- and medium-scale home industries, science and technology should be able to develop technologies which also take into consideration the ecology of the industrial environment. Science and technology services in the field of standardization, instrumentation, calibration, quality control, and information should be further developed. The educational system is equally important and must support such development.

Derived from the 1978 Guidelines of the State formulated by the Congress and the development problems mentioned above, Indonesian policy on industrialization will be focussed on the sectors shown in Figure II.3.1.

If we study these sectors, we can see that the Indonesian metrologist is facing quite a broad spectrum of problems. Advanced technology is applied in the first two sectors from which the product is mainly for export. Here metrology is unavoidable and quality must meet export requirements. For example, liquified natural gas which Indonesia is exporting should be backed by an adequate metrology capability, and also their export minerals need such support. For the third sector, the level of measurement capability will depend on the level of product requirements, but again metrology should be there. For the last three sectors, still another level of metrology is needed.

Indonesian policy on industrialization will be based on a balance of agriculture and industry; thus, metrology will have to take a part in agricultural activity. For example, in determining the quality of fertilizer distributed to the rural areas, metrology will have a role.

Other examples include the moisture content of rice, the effectiveness of storage systems, and testing of other agricultural products which have to meet certain requirements or standards.

A practical example by which LIN-LIPI has shown the importance of metrology is in answering a request of the Department of Logistics by producing a simple measuring instrument to measure the grade of "unshelled" rice. Based on an aerodynamic effect, we could separate the unshelled rice into three fractions: full, half-full, and empty shells. With this equipment, the Department will decide the price and will also provide efficient storage. Thus we see that each country faces a different systems approach and level of metrology, but metrology itself is essential.

D. The Implementation of Metrology

After looking at the problems, we have to discover the way in which to implement metrology properly. If we want to have an assured impact on industrial development, we must become a part of the industrial cycle. I mentioned earlier that we need to render services directly to industry and help raise its productivity. One feasible approach is to optimize or mobilize all available metrology means. This does not necessarily mean only government institutions but private companies might also join. With a wider front, the impact on industry will be felt more. This kind of network will help build up a strong metrological infrastructure.

The second important effort has to come from the Government to support these activities as public overhead efforts. They cannot be left to private companies alone because of the long-term nature of the profit returned.

The third effort of these activities should be stress on metrology work which has a direct relationship to productivity.

The fourth action, which will be very essential to the success of this effort, is coordination. Here a National Center is needed to be responsible for planning, organizing, stimulating, and controlling, without neglecting the primary goal of the netowrk, that is, to render services directly to industry. Of course, as metrologists we should not only be looking from the point of view of services alone, but also in the broader sense that we will encounter at a later stage of national development because metrology is an integral part of research and development, design evaluation, quality control, and product improvement.

Economists use the term infrastructure to mean services such as transport, power, education, etc., in which a society makes a long-term capital investment and for which the investment itself may not return a profit in the short term. They are based on social or public

overhead capital and are usually partly publicly funded for that reason. Thus is metrology a part of the infrastructure.

Another important point to be mentioned is that these activities should partly be paid for by industry. This is important to raise the sense of belonging and maintaining the growth of these activities and also to gain higher respect from industry. On the other hand, the metrologist will have a more responsible feeling toward industry. In short, we should reach the condition that metrology can be run as a non-profitmaking businesslike organization.

Such approaches as these will stimulate industry to a closer relationship with metrology. I would call this kind of action a "push effort," and hopefully, the "pull effort" by the users will come afterwards.

The Government of Indonesia has taken measures in this direction; the National Program for Calibration, Instrumentation, and Metrology has the objectives mentioned above. The National Institute for Instrumentation--Indonesian Institute of Sciences (LIN-LIPI)--has been directed to be the center to manage the national system. This center should not only be active on the management side, but also should have the necessary metrological capabilities to render services to other centers.

The first step taken has been to establish a National Network for Calibration with membership by all institutions, including industrial organizations who have a certain level of calibration capability. For this a National Committee for Calibration was inaugurated in January 1978 to manage and develop the network. In this way, a direct link to industry can be easier without losing the sense of belonging of each center. I think we are all aware that this kind of approach has already been established for some time in other countries, such as in England with the British Calibration Services (BCS), and in November 1977, in the Federal Republic of Germany. If I am not mistaken, India is also making some efforts in this direction. For clarity, reference can be made to Figures II.2.2 and II.2.3 in the preceding paper in this volume by Dr. Probine.

In the calibration, instrumentation, and metrology program, other activities are also included, such as the establishment of a National Center for Calibration, Instrumentation, and Metrology, precision measurement training programs, the dissemination of instrumentation technology know-how, and the setting up of professional instrumentation associations and international relations.

In the two earlier parts, the study of the problems and its implementation, I came to the conclusion that metrology could play a significant role in developing industrialization. But we still have to emphasize a popular expression used by metrologists, that precision measurement is a means to an end, and not an end in itself. With this

expression, we know where we are; in a developing country, initiative must be taken by the metrology community to take part actively in developing industrialization. This approach would mean that metrologists could join the development process and prove that metrology can be meaningful for the nation's development.

E. Suggested Improvements

Finally, I would suggest some improvements which I think could help us attain a suitable metrology structure; at least the following improvements can be undertaken.

1. A national program should be established through operations analysis and systems engineering studies; in particular, stress should be laid on applied metrology. This program should be an integrated one, covering at least the four fields--commerce, industry, technology, and science.

2. Most developing countries should stress their work on applied metrology, which will give direct support to industry and also support R & D activities.

3. A national metrology network should be established with adequate government support. For this the following steps are needed:

(a) First, select a minimum number of layers in the structure, consistent with logistics, with prime attention focused on the basic layer where research/development and production measurements take place. Be sure these measurements are correct; they are most important in the structure.

(b) Second, establish a periodic calibration program for all test and measuring equipment to insure that its precision remains within prescribed error limits. Establish how often to test, specify what standards to use, and arrange to test the standards themselves periodically. Ensure that a centralized point of reference is available to support the accuracy of the entire measurement system.

(c) Third, insure that trained measurement specialists are available to develop and maintain guidelines for the test methods to be used by others. The same specialists should be used to develop new test and measuring equipment necessary to meet demonstrated accuracy requirements. Training should include not only one of the usual engineering or physics curricula, but should extend to a working knowledge of statistics and its application to measurement. Systems analysis, especially as it applies to the economic and financial aspects of manufacturing and testing, would be useful. Design engineers also should receive formal training in measurement techniques

and practices so that they will appreciate the effect of their tolerance selections on overall quality and cost.

4. A National Center for Metrology is essential as a technological center and for system management. The Center should have responsibility for developing a national metrological capability, for its dissemination, and for maintaining the national physical standards. This institute should have close cooperative relations internationally and regionally.

5. Metrology is part of an infrastructure, and for this reason, government support is essential, without neglecting private organizations which should also be stimulated to assume their responsibilities. For the initial activity, government support is unavoidable.

6. There should be a nationwide network of instrumentation centers; at least one well-equipped center of instrumentation for each geographical area of operation would help to attain the following goals:

(a) To train operators and maintenance personnel.

(b) To give advice regarding acquisition of instruments.

(c) To supply secondary standards (each center would have primary calibrated standards).

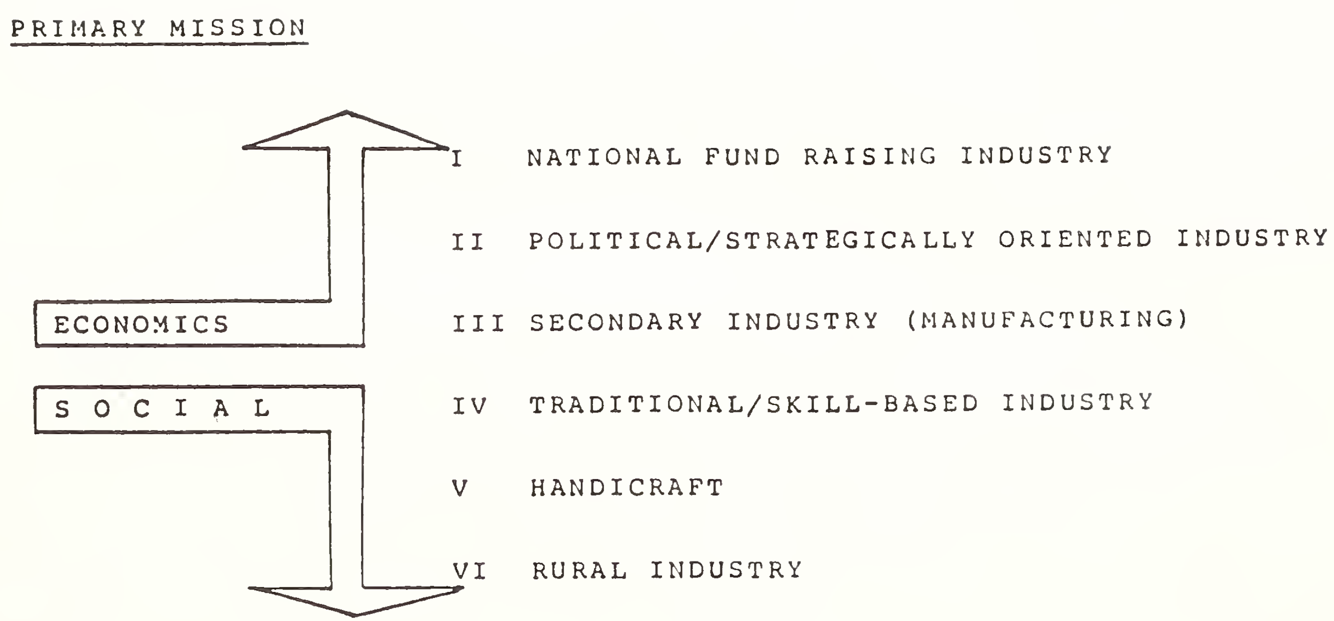
(d) To carry on measurements involving great responsibility.

(e) To operate a pilot laboratory to find solutions for special problems in applied metrology.

(f) To provide an emergency maintenance service in the area.

7. Regional cooperation among developing countries should be established and should stress the exchange of experience and information, the holding of technical seminars, interlaboratory checks, and regular institutional and personal contacts.

8. International cooperation with advanced metrological institutions should place more stress on rendering assistance to developing countries by providing up-to-date information, critiques of programs, assistance in selection of new instrumentation, advice on management problems, standards (including reference materials), local consulting expertise, fellowship exchange programs, and other means.




INDUSTRIAL CLASSIFICATION

Figure II.3.1

## II.4 ASSESSMENT OF THE REQUIREMENT OF INDUSTRIES/INSTITUTIONS FOR SERVICES IN THE FIELD OF STANDARDS

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### A. Introduction

A major objective of standardization is to establish and improve the quality of products, services, and procedures by virtue of the establishment of high quality basic standards.

For this objective, the standards laboratory of any country acts as a national focal point for the science of measurement for maintaining and developing methodology for the realization of internationally agreed-upon standards in mass, length, time, temperature, luminosity, electrical, and radiation measurement quantities. In view of this, it has been decided to develop the National Physical and Standards Laboratory (NPSL) into a prime in-house physical and chemical science laboratory.

A nucleus of the NPSL was started at Islamabad in January 1974 in collaboration with the Ministry of Industries, Government of Pakistan. This unit has been instrumental in providing an institutional framework and laboratory facilities for the introduction of the International System of weights and measures in the country.

The NPSL scheme was approved by the Government of Pakistan in May 1977. The laboratory at present is equipped for the calibration of mass and length only to the level of working standards. The present nucleus of the NPSL is housed in the University of Quaid e Azam. It is being planned to equip it at the reference level.

The construction of the building for NPSL, the procurement of essential equipment, and the growth of relevant scientific manpower for the development of essential standards and techniques of calibration will take at least three years. To comprehend the immediate needs of industry in physical and materials standards, it was decided to undertake a comprehensive survey of selected industries and organizations in the country.

### B. Objective of the Survey

The aims of the survey were:

1. To find out the present position of the precision in measurements being exercised in the country leading to the determination of immediate calibration requirements and fixing of their priorities.

2. To provide an opportunity to the NPSL scientists to have firsthand knowledge of the quality control being maintained in industry and to hold discussions with the experts at various organizations in order to have their opinion/advice on the functional setup of the NPSL.

## C. Data Collection

With the above aims, a survey of various industries and organizations was undertaken. A questionnaire (ANNEX II.4.1) was also dispatched to various industries and organizations. A list of the organizations visited by the team is attached as ANNEX II.4.2.

It may be mentioned that, for the survey under reference, data collected through visits has been more fruitful than the replies received through the mail. A mutual exchange of views and explanation of the purpose of the visit and the questionnaire prompted the experts to give detailed information.

## D. Findings and Observations

The status of the standards and the measurements of the fundamental units being maintained/undertaken in the country and other relevant information about materials, etc., are listed below:

### 1. Basic Units

a. Mass: Mass measurements at 0.1 mg precisions are being carried out at almost all the organizations visited. The measurement at 0.01 mg is being maintained at places like the Pakistan Mint, textile mills (e.g., Kohinoor and Abbasi Textile Mills), the Cotton Research Institute, Lever Brothers, and pharmaceutical firms (Marker Alkaloid and Pfizer). All these organizations (except Pakistan Mint) utilize imported single pan balances to perform the measurements.

No facilities exist anywhere in Pakistan to calibrate these balances except at the Azam Instruments, Karachi, which in fact makes a check only of the vernier scale without using any reference weights.

Reference standard weights and balances (two pan) are available only at the Pakistan Mint, which possesses a set of certified weights for calibrating the weights (up to the secondary level) manufactured there.

b. Length: Measurements at a micron precision are being undertaken at quite a few organizations/industries, viz., the Pakistan Ordinance Factory, Heavy Mechanical Complex, Pakistan Machine Tool Factory, Pakistan Industrial and Technical Assistance Center, Pakistan Swiss Training Center, and Pakistan Engineering Corporation. The equipment used for these measurements is

calibrated against standard slip gages. The slip gages in turn are not at all being calibrated or standardized by any organization in Pakistan.

c. Temperature: Accuracy to better than 1° C was not encountered in any of the industrial processes. However, measurements to within 0.05°C or better are made at the Meteorological and Research Laboratories. In industry, temperatures as low as -180°C (industrial gases) and as high as 1000°C to 1800°C (refractories, glass, and steel industries) are being used.

The devices being generally used for temperature measurements are mercury thermometers, thermocouples, and pyrometers. There are no facilities to calibrate these instruments except for thermocouples at Pakistan Air Force, Heavy Mechanical Complex, and Honeywell, Karachi.

It may be mentioned that the Meteorological Department has indicated its requirement of calibrating mercury thermometers to 0.1°C. Similarly, the glass industry at Hasanabdal and Karachi was looking for advice/help in improving its temperature measurements from the presently maintained accuracy of 5°C to 1°C.

d. Ampere: This is the basic unit to which all other electrical parameters are linked, e.g., the volt and coulomb and the units of resistance, capacitance, and inductance. Measurements of these parameters are being made at various concerns, e.g., Pakistan Cables, Siemens, Pakistan Air Force, Philips.

There are no facilities to standardize the relevant measuring equipment except at Pakistan Air Force, Karachi. The Pakistan Air Force is in a position to calibrate these parameters to a high accuracy but has to periodically send its own standard equipment abroad for calibration and authentication.

e. Time: The team did not come across any place where accuracy of better than one second in time measurement was needed.

Some work on time standards is being performed at the Space and Upper Atmosphere Research Council Organization (SUPARCO), which is using standard frequency vibrators for this purpose. Also, frequency measurements which are inversely related to time are being made to an accuracy of 1 part in 10" at the Pakistan Air Force and SUPARCO.

f. Luminosity and Amount of Substance: There is no mentionable work being carried out on luminosity measurement except at the Central Testing Laboratories, Karachi, where the luminosity of electric bulbs and tubes is measured against imported standards on a commercial level.

As to the amount of substance which involves mass measurements of atoms and other fundamental particles, no work is being done in Pakistan.

2. Materials

a. As to the standard reference materials, the Pakistan Mint possesses about 40 samples of ferrous and non-ferrous metals and alloys (e.g., Al, Bi, Mn, Ni, Zn, brass, steel) certified by the British Royal Mint for chemical composition. Similar standard ferrous and non-ferrous materials are also used at the Pakistan Machine Tool Factory, Pakistan Ordinance Factory, and Railway Steel Shop. Some imported standard materials (e.g., Al, Cu, steel, brass, insulating papers, PVC cables, enameled wires, and enamel paints) are used as references by Siemens, Karachi. These materials are certified for composition/electrical properties by the parent office of Siemens in Germany.

Apart from the above, there is no other place where standard reference materials are being maintained/utilized.

At almost all the quality control laboratories, imported chemicals/materials or "Analar" or British Drugs House grade are being used for analytical purposes. It would be pertinent to emphasize at this juncture that there is no laboratory in the country equipped to perform material/analytical testing at the reference level.

b. For material testing, machines for testing tensile, compression, impact, and hardness are being used extensively--notably at the Pakistan Ordinance Factory, Heavy Mechanical Complex, Pakistan Machine Tool Factory, textile units, Siemens, Central Testing Laboratories, Railway Workshops, Pakistan Engineering Corporation, Karachi Shipyard, and other engineering works. There is no proper arrangement for calibrating these machines, except that some firms have an arrangement with the suppliers for a periodical checkup. M/s. Avery Scales was found to be the only supplier capable of routine servicing of weighing and testing machines at the commercial level.

3. Discussions at Various Organizations

a. Discussions with the quality control managers and other experts at various organizations revealed that quite a few people in our country are appreciative of the functions of and the need for a standards laboratory.

Nevertheless, the experts at places like the Pakistan Engineering Corporation, Central Testing Laboratories, Pakistan Air Force, Heavy Mechanical Complex, Pakistan Machine Tool Factory, Karachi Shipyard and Engineering Works, and Pakistan Meteorological

Department emphasized an immediate need for the NPSL to provide calibration facilities and serve as a reference laboratory in cases of dispute. The survey team came to know about the differences which sometimes arise between two parties on the specifications of a given material.

The quality control managers of certain firms indicated that for keeping instruments in proper functioning order, not only are experts required to repair the equipment, but also a more serious problem is that of the non-availability of spare parts.

The need for having a strong instrumentation section at the NPSL for calibration and advice on repairs was emphasized by some industrial concerns.

b. Apart from the need of having a reference laboratory in the country, the experts from certain quarters (e.g., Pakistan Engineering Corporation at Lahore and Pakistan Machine Tool Factory at Karachi) suggested that standards for the products being manufactured in the country should be fixed so that competition within the country could boost the quality of our products and exports.

At the moment, there is a variety of standards for products manufactured in the country, and consequently, it is difficult to compare quality and prices. Organizations like Railway Steel Shop and Workshops follow their own specifications. Similarly, Pakistan Machine Tool Factory and Pakistan Engineering Corporation have their own standards.

Organizations like Philips, Pfizer, and Glaxo follow the specifications set by their parent companies. Then there are companies which comply with the standards set forth by the Pakistan Standards Institution (PSI), e.g., for refractories, cement, food items, carbon paper and ribbons, etc. There are still others like Sind Alkalies, who follow British Drugs House standards, e.g., for the production of sodium bicarbonate. On the other hand, manufacturers of nuts and bolts, cane crushers, chaff cutters, etc., do not follow any standards at all, either in connection with the materials used or with the product. This appears to be a complex problem, and a suitable solution shall have to be found. The PSI, which is responsible for formulating such standards, is not able to cope with the insurmountable volume of work in this field. So far, the Pakistan Standards Institution has set forth 1,400 standards out of which only 600 have been published.

c. Finally, it may be mentioned that the industry, apart from the calibration of equipment, would also need advice on improved analytical techniques and methodology for maintaining required standards.

4. Quality Control in Industry

a. With respect to the position of quality control in industry in our country, the overall position is summarized below.

A number of small concerns engaged in engineering work (viz., making of cane crushers, chaff cutters, nuts and bolts, etc.) and textiles (weaving and sizing units) visited at Faisalabad and Multan do not exercise any quality control as far as objective measurements and materials are concerned.

As to the chemical industry, it was observed that quality control was only nominal. Similarly, there was no quality control at the dairy product plants at Faisalabad. However, there were good quality control facilities at Pak Arab Fertilizer Factory, Multan, and Sind Alkalies, Karachi. Pak Arab Fertilizer had the problem of non-availability of standard gas mixtures for chromotographic analysis of natural gas.

Good quality control facilities are being maintained and exercised at all the big engineering, electrical, textile, pharmaceutical, and vegetable ghee and beverage manufacturing concerns. The quality control at these companies involves measurements of mass, length, angles, volume, temperature, time, electrical parameters, luminosity and pressure, and techniques like microscopy, chemical and biochemical analyses, chromotography, spectrophometry and spectrography, etc.

It may be mentioned here that the functioning of the various quality control and other laboratories was in general not very satisfactory. A very prominent reason, among others, for this was found to be the fact that the trained technicians and scientists leave their jobs in pursuit of better remuneration in the country or abroad. This applies particularly to the government organizations and was pointed out to the survey team at the Pakistan Industrial and Technical Assistance Center, Central Testing Laboratories, Karachi Municipal Corporation, Karachi, etc.

E. Suggestions/Recommendations

In view of the findings of this survey, it is being considered to develop NPSL along the following lines:

1. NPSL would have to be first equipped for realization and calibration of the units of mass, length, temperature, current, luminosity, and time.

This suggestion is obviously made on the grounds that the measurements on these and the derived units are being made to high accuracy and are expected to improve further in due course.

Among the derived units, immediate attention will have to be paid to the calibration and standardization of volume and pressure measuring devices, in particular, in view of their extensive use in industry.

2. Standard reference materials for material testing and analyses will have to be organized. It will also be necessary to arrange for equipment of the highest possible accuracy for material testing and physico-chemical and chemical analyses.

3. A strong Instrumentation Section will also have to be created at NPSL. To start with, this section could be comprised of electrical/ electronics, mechanical, and chemical engineers. This section should not only have the capability to calibrate equipment but should also be well versed in the technology to repair/install and operate sophisticated instruments, e.g., weighing balances (of accuracy of 1 mg or less), tensile testing machines, length measuring devices (of accuracy to less than 1 mm), spectrophotometers (visible, IR, UV), polarimeters, refractometers, pH meters, flame photometers, potentiometers.

The Instrumentation Section will have the following functions:

a. To provide calibration services in addition to advisory services for the maintenance and repair of equipment.

b. To provide information on the comparative accuracy of instruments for some measurements.

c. To improve accuracy in measurement.

d. To design and develop equipment for which we have appropriate sources.

The importance of a strong Instrumentation Section in the NPSL cannot be overemphasized, as the NPSL would be the custodian of the prototype and reference standards of measurement to which the accuracy of all the equipment is eventually to be traced.

4. In order to develop the NPSL on proper and useful lines, it will be essential to assign some senior scientists in all the relevant fields to chalk out a feasible program of work in accordance with the functions of the NPSL.

5. It is also desirable that some scientists be developed and trained for maintenance of reference standards and calibration techniques for the basic units of measurements, viz.: mass, length, temperature, current, luminosity, and time. Although a continuous program of manpower development shall have to be followed, the training on the basic units of measurements needs top priority.

Quality control of various industrial products will require proper and strict enforcement and the regulation of standards for which an organization other than NPSL will be needed. Offhand one could, however, foresee a number of problems which would arise as a result of the prevailing social environment. For example, adhering to strict control measures would require extra expenditures and efforts to maintain the desired level of measurement and accuracy on the part of industry. This may, however, be difficult to achieve under the prevailing socio-economic conditions and cultural traditions which perhaps are common to most of the developing countries. The indigenous industry is fairly free to utilize substandard materials with lower precision and quality in the end product. It is well to realize that securing compliance and organizing facilities for the satisfactory examination and testing of materials, processes, practices, and products according to the standards prescribed needs fundamentally, as a prerequisite, a standard performance and execution of the basic functions and a reasonable stability of the national government in a developing country. This, however, should not prove to be a stumbling block in the way of establishing a standards laboratory.

As a starting measure, the NPSL would consist of two divisions, namely (a) a Physical Standards and Measurements Division and (b) a Materials Division. The first will consist of (a) primary physical standards, (b) development and production of secondary standards, and (c) electrical standards. The second will consist of (a) reference standards and (b) an advisory services and testing section, including physico-economic techniques and instrumental analysis.

ANNEX II.4.1

## SURVEY QUESTIONNAIRE

NATIONAL PHYSICAL AND STANDARDS LABORATORY
ISLAMABAD

### Part A

1. Name of the organization.

2. Do you have a Quality Control Laboratory?

3. Could you name the parameters (mass, length, volume, temperature, time) for which your requirements of measurement are strict?

4. If the answer to question 3 is yes, please state the range and accuracy of each parameter.

5. Name the standard equipments, with their measuring accuracies, that you have for measuring the above-mentioned parameters.

6. Do you have some regular arrangements (local or foreign) for checking/calibrating the reliability of your standards/standard measuring equipment? Please also indicate the relevant financial involvements.

7. Are you obliged by any national or international law to maintain certified standards or measuring instruments?

8. Does the metrication program affect your industry in any way? If so, please indicate in what way.

9. Are you looking for any guidance and help in remodeling your equipment according to metric units of measurement? Please list your requirements.

### Part B

1. Are you using or manufacturing any standard reference material? If yes, please give specifications.

2. What arrangement do you have for checking/calibrating your standards/standard equipment?

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If you have any comments or suggestions to make, please feel free to do so.

ANNEX II.4.2

## LIST OF INDUSTRIES/ORGANIZATIONS VISITED

### Lahore

1. Pakistan Mint
2. Lahore Engineering and Foundry Works (LEFO)
3. RECO (Kotlakhpat and Badami Bagh)
4. Pakistan Railway Steel Shop and Workshop
5. Pakistan Oxygen Ltd.
6. Industrial Gases
7. Punjab University
8. Training School for Weights and Measures
9. Department of Weights and Measures
10. PITAC
11. Central Testing Laboratories (CTL)
12. Packages Limited

### Faisalabad

1. Lyallpur Chemical and Fertilizer Co.
2. Kohinoor Textile Mills
3. Chand Engineering Co.
4. Punjab Engineering Co.
5. Itifaq Industries
6. Taj Mohammad and Co.
7. Aizad Beverages Limited
8. Seven Up Factory
9. Agricultural University
10. Rafhan Maize Products
11. Lyallpur Dairies
12. Popular Dairies
13. Nalibar Dairies
14. Crescent Sugar Mills
15. Champion Wall Clock Co.
16. Mumtaz Foundry
17. Pakistan Land Chemicals
18. Lyallpur Motor Co.
19. Pervez Industry
20. NIAB
21. Seith Mohammad Tufall & Brothers
22. Unis Brothers Scales Industries
23. Lyallpur Engineering Co.
24. A-One Nuts and Bolts
25. Shahid Sizing Co.
26. Rahim Industries
27. Batala Crown Engineering Works
28. Salim Brothers

29. Iqbal Nasir Weavers
30. Salim Wearing Factory
31. Asiatic Chemicals

## Multan

1. Pak Arab Fertilizer Factory
2. Pakistan Juice Co.
3. A. N. H. Laboratories
4. Omega Laboratories
5. Virgo Chemicals
6. Sarwar Scale Works
7. Chaudri Engineering Works
8. Qazi Engineering Works
9. Directorate, Labor Welfare Department
10. Pakistan Engineering Co.
11. Cotton Research Institute
12. Coca Cola Factory
13. Pakistan Oil Mills
14. Sarwar Foundry Works
15. Multan Engineering Works
16. Golden Kanda Factory
17. Pakistan Engineering and Foundry Works
18. Gul Mohammad and Sons or Universal Mechanical Works
19. Fahim Engineering Co.

## Rahim Yar Khan

1. Lever Brothers
2. Abbasi Textile Mills
3. Technical Trading Center

## Karachi

1. Pakistan Machine Tool Factory
2. Pakistan Swedish Training Institute
3. General Refractories
4. Prince Glass Works
5. Sind Alkalies
6. Karachi Shipyard and Engineering Works
7. Glaxo Laboratory
8. Weight and Measures Department
9. KMC Food Laboratories
10. Azam Instruments
11. C. T. L.
12. P. S. I.
13. Burmah Oils
14. Pfizer Limited
15. Honeywell Zelin Ltd.
16. Philips Electrical Co.
17. National Fiber Industry
18. Kohinoor Razor Blade

19. Avery Scales
20. AB Beverages
21. Atlas Rubber and Plastic
22. Karachi Carbon and Ribbon Factory
23. EMI (Pakistan)
24. Exide Battery
25. I. C. I.
26. Metal Industries
27. Pakistan Paper Products Ltd.
28. Asbestos Cement
29. Seimens
30. Ahmed Food Industries
31. Pakistan Cotton Research Institute
32. Wool Test House
33. Chemical Coating Industries
34. Metlex
35. Aluminum and Plastic Industry
36. Pakistan Meteorological Department
37. P. S. T. C.
38. SUPARCO
39. PAF Maintenance Unit Drigh Road
40. Pakistan Cables

## Quetta

1. Marker Alkaloid
2. G. S. P.
3. Department of Weights & Measures
4. Sorrange Mines
5. Weights and Measures Laboratory (Labor Department)
6. University of Baluchistan

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## II.5. A NATIONAL CAPABILITY IN METROLOGY IS ESSENTIAL TO INDUSTRIAL DEVELOPMENT

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### Preamble

First of all, I would like to congratulate NBS and K-SRI on the plan for conducting this Regional Seminar on Metrology. I also wish to take this opportunity to express my profound thanks to Dr. Zae-Quan Kim for his kindness in inviting me to this special occasion.

### Introduction

The concept of magnitudes of quantities and comparative measurements enters into every branch of industry and technology, no matter how primitive, and into every orderly exchange of goods. We find more or less clear ideas about magnitude and measurement even among the earliest organized communities. They had the notions of magnitude, including those of length, area, volume, weight, and time. The diversity and uncertainties of units of quantity, which were the bases of exchange of commodities and primitive technology, had forced even the ancient communities to try to improve their systems of measurement and to make their units more rigorously defined.

Thus, we find that an improved system of units and measurement was in use in ancient Babylon. The old civilizations in India, China, Persia, Egypt, Greece, and Rome bear witness to more elaborate and perfected systems of weights and measures. Standard units had been created and were preserved under the authority of the country.

However, there were peculiarities in the different solutions adopted at different times and places. These individualities were often patterned after the environment in which each civilization had flourished. The lack of rapid means of communication of the system, up to relatively recent times, prevented a significant cross-fertilization of ideas. With the advent of the industrial revolution and the growth of science and technology, the requirements for exact definitions and reliable methods of precise measurement became more stringent. Simultaneously with these increasing demands, the progress of science and technology also provided the means by which these demands could be met.

As we are aware, weights and measures have now become much more elaborate and precisely based, conforming to much greater exigencies of accuracy, reliability, and producibility which are essential for modern technology and to the growth and many ramifications of trade and commerce.

Thus metrology is of fundamental importance in the economy of every country. Without it, no science, technology, trade, or commerce could be possible.

## The Development and Realization of Concept of Metrology in Industry

Most of the developing countries are striving for a rapid improvement in human welfare, education and material wealth, etc. Fulfillment of their hopes rests largely on rapid economic growth, which in turn is rarely attainable by the marketing of raw materials alone. Governments and leaders guiding the destinies of most of the developing countries have thus reached one common conclusion: a prerequisite for achieving the hoped for progress is rapid industrialization, leading to the manufacture of goods both for domestic consumption and, wherever possible, for export.

However, to sell successfully the goods resulting from industrial production, especially in the fiercely competitive world markets, it is essential that they conform to defined standards of quality and uniformity. Quality control is thus very much an urgent concern, and quality control implies good measurement. But concern for quality of the end product is not the sole reason for regarding metrology and measurement as a vital step in the industrialization of any nation. Control by accurate reference to a well-defined measurement system is usually essential for the very success of the production process itself. Metrology and measurement play an essential part in successful progress toward industrialization. As the methods of measurements have improved, so has the progress of industrialization in the world. Metrology is said to be the only thread which ties together product development, which includes research, development, testing, evaluation, construction, and finally improvement of product based on prototype performance. Product manufacture, process monitoring, and product testing can, by appropriate metrological applications, ensure that the product actually delivered is reasonably similar to the prototype that was developed and the product that was promised. Without these, the cost will also increase, and the final product will have a different quality or performance from that anticipated and promised. It is for this reason that government and industry leaders should recognize the role that metrology plays in the financial health of every company and the economic development of the industry.

In some instances, some manufacturers do not subject their product to testing and quality control. This is because they feel that they can and are willing to take the risk of customers' complaints by providing free replacement services. Products such as even those of high cost, like watches, cameras, and radios, have been treated in this manner. In the long run, manufacturers realize that the cost will be higher and the names of their companies tarnished. Sales would begin to drop, and the prospect of exporting the products would weaken. The need for testing is even more critical or even mandatory where the products

affect safety, life support systems, intensive care equipment for hospital wards, and national security systems. In such systems, metrology comes into play to provide the basis for testing and to ensure that the industry turns out products which pass the required specifications.

Probably the biggest problem faced by most of the developing countries at present is the lack of a uniform system of basic units. Instead there exists a diversity of types of weights and measures. The units and their denominations may differ for different products and in different parts of the country. Often the units vary from locality to locality. Thus there exists a variety of units with different values, causing difficulties and confusion in trade, technology, and education. The only means to overcome this problem and to prevent misunderstanding and conflicts, which otherwise may cause mutual distrust, is by establishing a uniformity of national units of measure. This can only be achieved by mastering the fundamental principles of metrology.

Metrology provides the foundation on which the following services can be made available:

1. To maintain an accurate physical standards system as a reference for all measurements which are traceable internationally so that confidence can be established.

2. To establish a periodic calibration program for all test and measuring equipment to ensure that its precision remains within the prescribed error limits.

3. To provide trained measurement specialists.

4. To recommend proper process monitoring tolerances.

## Conclusion

Metrology, the science and technique of measurement, is of fundamental importance in the economy of every country. The experience of many countries has shown that the problems of economic development can be successfully solved only in a country that has an effective metrological service. It is as a result of this enlightenment that my country, Malaysia, among many other developing countries, has embarked on a program of developing a national standards laboratory as a technical guide agency in the national industrial development program.

## SESSION III

## A NATIONAL CAPABILITY IN METROLOGY
## IS ESSENTIAL TO INDUSTRIAL DEVELOPMENT -
## BUT WHO IS AWARE OF ITS ESSENTIAL
## SUPPORT OF INDUSTRY AND GOVERNMENT?

## III.1 THE NATIONAL MEASUREMENT LABORATORY AND AUSTRALIAN MANUFACTURING INDUSTRY

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### Summary

A short description is given of the National Measurement Laboratory's established methods for transferring measurement technology to Australian industry and of some changes of emphasis that are taking place to meet the requirements of the future.

### Australian Manufacturing Industry

In Australia, manufacturing industry accounts for about 20 percent of the gross domestic product, of total exports, and of total employment. For a nation of only 14 million people, the range of the industry is surprisingly broad and is comparable to the manufacturing base of developed overseas countries. The industry is geared more for domestic needs than for export and, consequently, is often unable to benefit from the economies arising from a large volume of production. A considerable body of opinion favors restructuring Australia's industry to make it more specialized, but there are conflicting views on how this might best be achieved.

There are about 37,000 manufacturing establishments in Australia, 70 percent of which are located in the south-eastern states of New South Wales and Victoria, with a great concentration in Sydney and Melbourne. The largest 200 firms account for about 50 percent of the output and dominate the capital-intensive industries such as steel, non-ferrous metals, chemicals, petroleum refining, and automobile manufacture. The great majority of manufacturing firms are small. Foreign interests wholly or partly own many of the firms, particularly the larger ones, and account for about 25 percent of the turnover.

Many of the larger Australian-owned firms have sizeable research centers. Foreign-owned ones, such as those in the oil refining and vehicle building industries, tend to rely heavily on imported technology, although some do have significant research activity in Australia. Most small firms confine their research to the solution of immediate problems.

### The National Measurement Laboratory (NML)

Australia is a federation of six states which for a long period were individually responsible for their weights and measures arrangements. NML was established by the national government in 1938 to provide readily accessible physical standards of measurement in Australia, but

wartime activities took precedence until 1945. NML was situated on the campus of the University of Sydney until late in 1977 when it moved to a new laboratory complex in the Sydney suburb of Lindfield. It is a constituent Division of the Commonwealth Scientific and Industrial Research Organization (CSIRO), and its functions are those defined for CSIRO in the Science and Industry Research Act (1949) and in the Weights and Measures (National Standards) Act (1960). Standards of measurement are maintained by NML for all physical quantities for which there are Australian legal units of measurement, except for ionizing radiations which are the responsibility of the Australian Atomic Energy Commission and the Australian Radiation Laboratory in the Department of Health.

In 1945 NML depended largely on imported standards, but subsequently it has developed almost all its basic standards ab initio. During this development it has profited a great deal from membership in many of the international committees formed under the Metric Treaty and from a close association with other national laboratories. In return, it has contributed a good deal to the international pool of knowledge on precise measurement, e.g., in the use of a calculable capacitor as a standard of impedance, in the periodic revisions of the International Practical Temperature Scale, and in the radiometric approach to photometry. It has always been NML policy that its standards work be undertaken in a research environment. The research undertaken is wider than the development of improved standards and includes, for example, physical research on materials and the measurement of important physical constants.

## NML's Established Relationship with Industry

NML's foremost responsibility to industry is to ensure that appropriate calibration arrangements exist so that industrial measurements can be readily based on the national standards. Even in a nation with such a small population as Australia's, it is not practical for one laboratory to calibrate more than a small fraction of the total number of standards and reference instruments required by the community. NML has found it increasingly necessary to confine its service to first-level standards and to rely on the multiplying effect of a hierarchy of other laboratories in government and industry.

Fortunately, this situation was foreseen while NML was first being established, and in 1947 an organization known as the National Association of Testing Authorities (NATA) was set up to encourage and coordinate the growth of measurement and testing facilities throughout Australia. Over one thousand laboratories currently hold registration by NATA, and about 25 percent of these can be regarded as multipliers of calibrations initiated at NML. The remainder undertake tests, such as chemical analyses and biological tests, that usually do not extend the traceability of the basic physical standards. NML cooperates closely with NATA in the calibration of standards, the inspection of laboratories, and where appropriate, the training of laboratory

staff. This gives NML experience in metrology in a wide range of industries and an excellent opportunity to learn of the changing needs of industry.

A second organization closely associated with NML in the dissemination of standards of measurement is the National Standards Commission (NSC). The responsibilities of this Commission include the legal aspects of measurement, the pattern approval of measuring instruments used in commerce, and the approval of verifying authorities, including the weights and measures authorities in each state. NML provides a scientific backup to NSC, and this provides another avenue for learning of industry's evolving needs for measurement.

A third method that NML finds valuable for communicating with industry is through participation in the work of the technical committees of the Standards Association of Australia. This Association publishes and promotes the adoption of standards in the form of specifications for materials and products, codes of sound or safe practice, methods of testing, nomenclature, etc.

NML also uses many less formal techniques for communicating with industry--through scientific and trade journals and appropriate CSIRO publications, through scientific and industrial conferences, through open days, patents, and the provision of training schools, and so on. The Laboratory also provides a consultancy service in measurement technology and in other areas of science and engineering where it has special competence. This leads to many laboratory tests and investigations which, though usually short-term in nature, are often of great significance to the client.

## Changes for the Future

NML's new laboratory complex provides further opportunities for close collaboration with industry. There is now ample space for many more measuring equipments to be set up permanently and available for use at short notice. Some of the more labor intensive systems are being automated to provide clients with a better service and to free staff for other activities. It is now more practical to accommodate guest workers from industry who might find it beneficial to research their own problems in the environment of a standards laboratory.

Careful consideration is currently being given as to whether NML should significantly reduce its basic standards research for a period and put more effort into applied research and industrial collaboration. For many physical quantities NML's standards now seem adequate to meet Australia's requirements within the foreseeable future, but it is recognized that there are risks in trying to stand still in any area of technology.

Industry's measurement requirements are also changing quite markedly, particularly because of the trend towards automated manufacture.

There is now less interest in manual measurements, whether these be on the factory floor or in the quality control laboratory after completion of the product. Instead, there is a growing demand for automated measurements on the production line itself, with the results feeding directly to an automatic control system. Such measurements often involve partly made products moving at high speeds, at non-ambient temperatures or in hostile environments, and are likely to call for fast non-contact methods. But like high accuracy measurements in the laboratory, they require a great deal of scientific ingenuity, and traditional metrologists can almost certainly make substantial contributions in this area.

Good communications are a vital factor for an efficient two-way flow of technology between government laboratories and industry, and it is widely accepted that face-to-face discussions represent the best form of communication. However, there are particular difficulties in the case of Australian industry because of the large geographical distances, the diversity of manufacturing firms, and their inadequate grouping. The problem is less severe with the larger firms, and 50 of these have continuing discussions with CSIRO through a body known as the Australian Industrial Research Group. A recent Independent Inquiry into CSIRO has suggested that, in order to facilitate communication with the smaller fragmented industries, the Government might assist them to form research associations. Largely in recognition of the communication problem, NML has recently established a small branch laboratory in Adelaide and is currently setting up another branch in Melbourne. It has established an Industry Committee from among its senior research staff and appointed a full-time officer to provide a closer technical liaison with manufacturers.

## Conclusion

The NML experience is that there is no easy single path by which to establish satisfactory interaction with manufacturers, and that many paths need to be attempted in parallel. It is comparatively straight-forward to cooperate with firms on immediate problems, but it is more difficult to identify the broader industrial issues where scientific and technical collaboration is likely to yield the greater benefits in the long term.

## III.2 A STUDY OF THE NATIONAL MEASUREMENT SYSTEM IN KOREA --AN INTERIM REPORT: HOW WE APPROACHED IT AND WHAT WE FOUND

Dr. Wun Jung
Korea Standards Research Institute
Dae Jeon, Korea

With the establishment of a new institute exclusively responsible for the enhancement of physical standards for metrological applications in Korea, a new survey of the National Measurement System (NMS) was carried out in 1977-78. The study coincides with the main theme of this Regional Seminar. We have tried to reconfirm where we stand, where to go, and how to get there. A partial analysis of the latest data is presented here in this talk, in the hope that this report would serve as an example of how to cope with similar situations in other countries, and that your advice to us will be elicited by this presentation.

### A. Background

The progress of the establishment of the Korea Standards Research Institute (K-SRI), from its conception, planning, actual execution, and various problems encountered in the process, was reported in a series of the previous NBS/AID Workshops: in the 1975 Regional Seminar in Singapore by Dr. Zae-Quan Kim, President (NBS SP 438), in the 1976 Workshop in Gaithersburg, U.S.A., by myself (NBSIR 77-1385), and in the 1977 Workshop by Dr. Choonghi Rhee, now in the process of publication. The rapidly changing needs of Korean industry in its development were presented by Dr. Jong Wan Choi, Administrator of the Industrial Advancement Administration, in the 1975 Workshop (NBSIR 76-1152).

In recent years, the heavy and chemical industries were expanded and the export volume of industrial products grew much more rapidly than anticipated in 1975, and the need for the strengthening of the NMS for the international traceability and nationwide dissemination of metrology standards was accordingly widely recognized.

### B. Groundwork of the Study

The National Industrial Standards and Testing Research Institute (NISRI, presently National Industrial Research Institute, NIRI) conducted an industrial measurement standards survey in 1973. The report provided a basis for planning and comparison. From 1976, the reports of the NBS study of the NMS in the United States became available, volume by volume. These reports, and the executive summary volume in particular, provided excellent guidance on what essential data should be collected in this kind of study. While the statistical data analyzed in the NBS study were supplied mostly by the U.S. Department of Labor, similar data were not readily available in Korea.

We had to work out a survey plan on how to collect data. Mr. H. S. Peiser and Dr. R. C. Sangster of NBS directly participated and helped us greatly in the formulation of detailed plans and procedures to fit the Korean situation.

With the finalized survey form (a schematic reproduction in translation is given in Annexes III.2.1 and III.2.2), we had to apply for the authorization of the Statistics Bureau of the Economic Planning Board as a designated agency for this survey, and it was approved as proposed.

C. Survey Procedure

The questionnaires on measurement instruments and calibration status were mailed out to 9,000 carefully selected industrial firms and public or governmental organizations and institutes. An official letter soliciting full cooperation and a booklet explaining the purpose of the survey and the mission of K-SRI accompanied each survey form. In order to double-check the responses and to get direct personal access to the practical problems at the workbench level, 800 major organizations and firms were selected for the field interviews by our research personnel.

Concurrent with the mailing of survey forms, teams of research and technical staffs visited 12 industrial complexes all over the country and held introductory seminars to promote a full participation in the survey. These seminar sessions stimulated the audience and resulted in many spirited discussions on metrology related problems in the laboratory and at workbench levels.

D. Data Collection

A total of 3,567 firms and 219 other organizations returned the questionnaires with information relevant to them. Most of the remaining recipients returned the blank forms stating that these questions did not seem to apply to them. Some were returned unopened due to changes in address. The firms responding to the survey represent 15.8 percent of 24,000, the number of manufacturing industrial firms of the country. In terms of product value, the firms represent 30.5 percent ($3.4 billion) of $11 billion of the total volume of the entire industrial products (as of December 31, 1976). Accordingly, the collected data have to be properly weighted to draw overall inferences for the entire system. This is the task we are pursuing at the moment, and the complexity involved in that task is the reason for the delay in the final analysis of the data. In the following discussions, we will be leaving out the weighting factors.

The field interviews covered 610 firms and 172 organizations in many areas of the country by 30 teams of ours and other temporary helpers from outside.

E. Analysis of Data

The information in the returned questionnaires, as confirmed and supplemented in part by field interviews, was fed into a computer and analyzed in various categories of instruments:

1. Measurement areas.

2. Precision and accuracy grades.

3. Countries of original manufacture.

4. Calibration status, calibrating organizations, and periods.

5. Utilization of those instruments and equipment and the number of years in use.

Overall pictures of the distribution of technical manpower and capabilities in the measurement areas were investigated, also.

1. The sorted data of measurement areas were correlated to the classification of firms and organizations according to their products and functions in order to draw a Korean version of the correlation matrix patterned after that of NBS studies.

The breakdown of 126,228 instruments in 782 field-interviewed firms and organizations was: 57,615 in the length area, 19,082 in the electrical and electronics field, 13,281 in the radio frequency area, and the rest in other fields. They were distributed among the firms as follows: 35,986 in electrical and electronics industries, 28,820 in mechanical industries, 15,849 in academic institutes, and the rest in others.

Compared to the 1973 survey data of 24,045 instruments in 839 firms and institutes, the number of instruments per unit (126,228 in 782 units) shows an increase of more than 5 times in the last four-year period. Together with the heavier distribution in the workbench levels, this reflects the wider utilization of the measurement instruments and keener awareness of the importance of the precise measurements in a certain portion of the industries.

2. On the other hand, the classification of the instruments by precision and accuracy indicates a rather slow increase in the high-grade instruments. The percentage of the precision unknown group remained high at 47 percent, compared to 34 percent (819) in 1973.

3. The change in the distribution of instruments in terms of the countries of manufacture between 1973 and 1977 shows a gradual but distinctive growth of the instrument industry in Korea in this period. The portion of Korean instruments increased from 8.6 percent to 21.7

percent. The close relationship between growth of the instrument industry and industrial development has already been amply demonstrated in advanced countries. An active assistance and effective support of the continued development of the instrument industries, which are mostly small and medium in size, are subjects we are looking into very carefully.

4. The calibration status data showed only a slight improvement (from 14 percent in 1973 to 19.6 percent in 1977), while the volume of the instruments rose sharply. A careful reexamination of 13,948 selected instruments of higher precision indicated up to 84.9 percent of them not being calibrated or unknown. This is the area a great deal of attention is focused on.

5. The responses to the question, "How many instruments are in active use and in what function (calibration, test/inspection, production)?" revealed that most of the instruments were in active use and only a small fraction (less than 9 percent) remained unused or out of order. The majority was used in production (38.4 percent) and calibration (35.4 percent). Testing and inspection used 5.7 percent and others 20.5 percent.

The data on the number of years in use showed that a large fraction (82.7 percent) of the instruments were acquired recently (less than five years), and hence, they were mostly recent models. Obsolete models of 6 to 10 years amounted to 12 percent and 11 years or more, 3.4 percent of the total employed. The rest (1.9 percent) were of unknown vintages.

## F. Concluding Remarks

In this talk, I have attempted to present a glimpse of an actual, down-to-earth effort to grasp "where we stand, where to go, and how to get there" in the area of metrology in Korea.

In order to strengthen the NMS of the country for enhancement of international traceability and nationwide dissemination of uniform measurement standards, a number of actions have already been initiated. In July 1978, a series of industrial measurement seminars was held in 11 industrial complexes to report the partial results of the present study. Based on this study, a team of 15 members from 9 standards and calibration organizations, including officials of IAA and the Joint U.S. Military Assistance Group-Korea, got together at K-SRI in August to hold a discussion meeting and conducted a week-long guided tour of each participating laboratory. This was intended to be the first step toward a closer interaction and cooperation among the laboratories and the groundwork for the formation of the Korean Association of Standards Authorities (tentative name). The association, it is hoped, will eventually become equivalent to the National Conference of Standards Laboratories (NCSL) in the U.S.A. and

similar to the National Association of Testing Authority (NATA) in Australia. It should strengthen the framework of the NMS in Korea by proper utilization of a laboratory accreditation system.

In order to cope with the rapid change in trend of world trade, the industrial structure in Korea is going through a period of transition and modification. Enhanced international traceability and dissemination of uniform measurement standards are the single most important area to remove the obstacle of the precision barrier. The growth of the instrument industry is nearly equally important. I have completely left out of the talk, the problems of the capability of the technical manpower in the measurement area, another area we are looking into very seriously.

We would greatly appreciate your advice and comments on our study report.

ANNEX III.2.1

1977 INDUSTRIAL PRECISION MEASUREMENT STANDARDS SURVEY (I)

International Compatibility Study of
Highly Technologically-Oriented Industry

Section:____________ Telephone:__________

Title:_____________________________________

Name:______________________________(seal)

Date of Record:___________________________

Korea Standards Research Institute

All inquiries connected with this questionnaire should be addressed to K-SRI (57-5106)

Note: The data recorded in this questionnaire will be kept confidential and will be used solely for statistical purposes in accordance with 8 and 9 of Korea Statistics Law.

## I. ORGANIZATIONAL OVERVIEW

| | | | | | |
|---|---|---|---|---|---|
| 1. Name of Organization | Name of Representative | Commodity or Revenue | 1. | 2. | 3. |
| 2. Address | | Main Source of Revenue | 1. | 2. | 3. |
| 3. Type of Industry | 4. Existence of KS Mark: Yes___ No___ | Output | | | |
| 5. Capital Stocks | | Gross Sales | | | |
| 6. Number of Employees | | Export | | | |
| 7. Manpower and Technology in Precision Measurement | (1) Scientist (2) Engineer (3) Technician (4) Craftsman (5) Semi-skilled (6) Apprentices (7) Metrologist (8) Total | | | | |

## II. STATUS OF MEASUREMENT INSTRUMENT

| Questionnaire Areas of Metrology | Mark "O" if used | Instrument of Stds. Used Name of Nomenclature | Purpose | Measurement Range | Highest Accuracy | Manufactured Country | Calibration & Certification (Yes or No) | Calibration Organization | Usefulness | Other Preferences (Quantity) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Length | | | | | | | | | | |
| 2. Angle | | | | | | | | | | |
| 3. Surface Finish & Surface Property | | | | | | | | | | |
| 4. Mass or Weight | | | | | | | | | | |
| 5. Volume | | | | | | | | | | |
| 6. Density | | | | | | | | | | |
| 7. Force & Torque | | | | | | | | | | |
| 8. Materials Testing | | | | | | | | | | |
| 9. Shock & Vibration | | | | | | | | | | |
| 10. Pressure & Vacuum | | | | | | | | | | |
| 11. Fluid Flow | | | | | | | | | | |
| 12. Time & Frequency | | | | | | | | | | |
| 13. Velocity & Revolution | | | | | | | | | | |
| 14. Electricity | | | | | | | | | | |
| 15. RF & Microwave | | | | | | | | | | |
| 16. Magnetism | | | | | | | | | | |
| 17. Acoustics & Noise | | | | | | | | | | |
| 18. Temperature | | | | | | | | | | |
| 19. Humidity & Moisture | | | | | | | | | | |
| 20. Radiometry & Color | | | | | | | | | | |
| 21. Spectrophotometry & Color | | | | | | | | | | |
| 22. Optical | | | | | | | | | | |
| 23. Radiation | | | | | | | | | | |
| 24. Chemical Analysis | | | | | | | | | | |
| 25. Standard Reference Material | | | | | | | | | | |
| 26. Others | | | | | | | | | | |

ANNEX III.2.2

# 1977 INDUSTRIAL PRECISION MEASUREMENT STANDARD SURVEY (II)

International Compatibility Study of
Highly Technologically-Oriented Industry

Korea Standards Research Institute

Supporting Organizations: MCI, MOST, IAA, KCCI, FKI,
KTA, KFSB, KGMA, KGMIC

Note: The data recorded in this questionnaire will be kept confidential and will be used solely for statistical purposes in accordance with 8 and 9 of Korea Statistics Law.

| I. ORGANIZATIONAL OVERVIEW | |
|---|---|
| 1. Name of Organization: | Name of Representative: |
| 2. Address: | |
| 3. Type of Industry: | 4. Existence of KS Mark: (yes) (no) |
| 5. Capital Stocks or Investment: | |
| 6. Commodity of Revenue: | |
| 7. Output: | |
| 8. Annual Sales: | |
| 9. Annual Exports: | |
| 10. Number of Employees: | |
| 11. Manpower and Technology in Precision Measurement: | |
| 12. Education and Job Classification of Metrology Related Manpower: | |

| Education Received / Job Classification | M.S. and Ph.D. | B.S. | Vocational School Graduate | High School Graduate | Middle School Graduate | Primary School | Others | Total |
|---|---|---|---|---|---|---|---|---|
| 1. Scientist | | | | | | | | |
| 2. Engineer | | | | | | | | |
| 3. Technician | | | | | | | | |
| 4. Craftsman | | | | | | | | |
| 5. Semi-skilled | | | | | | | | |
| 6. Apprentice | | | | | | | | |
| 7. Metrologist | | | | | | | | |
| 8. Total | | | | | | | | |

13. Status of Metrology Training:

| | 1. Number of People | 2. Training Place (or country) | 3. Name of Organization |
|---|---|---|---|
| 1. Training Completed | | | |
| 2. Training Planned | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| II. STATUS OF MEASUREMENT INSTRUMENTS | 14. Total No. of Items | | | | | |
| | 13. Uses | Others | | | | |
| | | Production | | | | |
| | | Testing | | | | |
| | | Calibration | | | | |
| | 12. Degree of Utilization | Minor | | | | |
| | | Moderate | | | | |
| | | Important | | | | |
| | 11. Operation Status | To Be Repaired | | | | |
| | | Not Operating | | | | |
| | | In Operation | | | | |
| | 10. No of Years in Use | Over 10 Years | | | | |
| | | 5 Years to 10 Years | | | | |
| | | 1 Year to 5 Years | | | | |
| | | Less Than 1 Year | | | | |
| | 9. Calibration Organization | | | | | |
| | 8. Last Date of Calibration | | | | | |
| | 7. Calibration and Certification Internal | | | | | |
| | 6. Calibration and Certification | No | | | | |
| | | Yes | | | | |
| | 5. Highest Accuracy (Ex. 0.01%) | | | | | |
| | 4. Measurement Range (Ex. 0~100mm) | | | | | |
| | 3. Manufacturer (Country, Company), Model | | | | | |
| | 2. Nomenclature | | | | | |
| | 1. Item No. | | | | | |

| III. STATUS OF SRM UTILIZATION | | | |
|---|---|---|---|
| No. | Classification | Sub-Classification: Mark "O" to those that are being analyzed or measured at your organization | Division Concerned |
| 2501 | High Purity Metals (for Microanalysis) | 1. Gold ( ) 2. Zinc ( ) 3. Copper ( ) 4. Lead ( ) 5. Aluminum ( ) 7. Tin ( ) 8. Others ( ) | |
| 2502 | Industrial Product Quality Control | 1. Standard Rubber ( ) 2. Rubber Chemical ( ) 3. Plastic ( ) 4. Turbidimeter ( ) 5. Segercone for High Temperature Measurement ( ) 6. Standard Color for Paint ( ) 7. Specimen for Dye ( ) 8. Specimen for Corrosion Test ( ) 9. Others ( ) | |
| 2503 | Standard Gases for Air Pollution | 1. CO Std. Gas ( ) 2. $SO_2$ Std. Gas ( ) 3. NO Std. Gas ( ) 4. Hydrocarbon Std. Gas ( ) 5. Zero Gas ( ) 6. Permeation Tube ( ) 7. Analyzed Liquid Sample ( ) 8. Others ( ) | |
| 2504 | Optical and Color Standards | 1. Wavelength Calibration ( ) 2. Luminosity Calibration ( ) 3. Refractivity ( ) 4. Reflectivity ( ) 5. Whiteness ( ) 6. Standard Color Filter ( ) 7. Others ( ) | |
| 2505 | Gases in Metals | 1. Nitrogen in Low Alloy Steel ( ) 2. Nitrogen in High Alloy Steel ( ) 3. Nitrogen in Cast Iron ( ) 4. Oxygen in Metal ( ) 5. Hydrogen in Metal ( ) 6. Gas in Non-metal ( ) 7. Others ( ) | |
| 2506 | Nonferrous Metal and Alloys (Disc and Sheet Form) | 1. Aluminum ( ) 2. Copper ( ) 3. Zinc Die Casting ( ) 4. Nickel ( ) 5. Lead ( ) 6. Tin ( ) 7. Others ( ) | |
| 2507 | Nonferrous Metal and Alloys (Chip Form) | 1. Aluminum ( ) 2. Copper ( ) 3. Zinc ( ) 4. Nickel ( ) 5. Lead ( ) 6. Tin ( ) 7. Selenium ( ) 8. Others | |
| 2508 | Primary Chemicals (For Standardization) | 1. Primary Chemicals ( ) 2. Secondary Chemicals ( ) 3. Elementary Analysis ( ) 4. Clinical Analysis ( ) 5. Organo-metallics ( ) 6. Ph Buffer ( ) 7. Gas Chromatograph ( ) 8. Others ( ) | |
| 2509 | Heat and Temperature | 1. Freezing Point ( ) 2. Melting Point ( ) 3. Colorimetry ( ) 4. Thermal Conductivity ( ) 5. Thermal Expansion ( ) 6. Thermocouple ( ) 7. DTA Calibration ( ) 8. Others ( ) | |
| 2510 | Radioisotopes and Radiations | 1. U, Pu Assay ( ) 2. Isotope Assay ( ) 3. X-ray ( ) 4. N.D.I Test ( ) 5. Others ( ) | |
| 2511 | Raw Materials | 1. Ores ( ) 2. Cements ( ) 3. Glass ( ) 4. Mineral ( ) 5. Refractory ( ) 6. Fertilizer ( ) 7. Steel Making Alloy ( ) 8. Others ( ) | |
| 2512 | Irons & Steels in Disc Form (For Emission Spectograph and XRF) | 1. Low Alloy Steel ( ) 2. Stainless ( ) 3. Tool Steel ( ) 4. High Temperature Steel ( ) 5. Maraging Steel ( ) 6. Cast Iron ( ) 7. Pig Iron ( ) 8. Others ( ) | |
| 2513 | Irons and Steels in Chip Form (For Chemical Analysis) | 1. Carbon Steel ( ) 2. Low Alloy Steel ( ) 3. High Alloy Steel ( ) 4. Stainless Steel ( ) 5. Tool Steel ( ) 6. Cast Iron ( ) 7. Pig Iron ( ) 8. Others ( ) | |
| 2514 | Thickness Standards (Coating Thickness) | 1. Copper ( ) 2. Chromium ( ) 3. Nickel ( ) 4. Zinc ( ) 5. Tin ( ) 6. Gold ( ) 7. Silver ( ) 8. Paint, Lacquer, Varnish ( ) 9. Others ( ) | |
| 2515 | Others | 1. Viscosity (Lubricating Oil, etc.) ( ) 2. Density ( ) 3. Specific Gravity ( ) 4. Vapor Pressure (Metal, etc.) ( ) 5. Others ( ) | |

## IV. STATUS OF SRM INVENTORY: To Record in This Questionnaire, Follow the Example Shown

| 1. Classification # | | 2. SRM Reserved | | | | | 3. SRM Required in the Future | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Class | (2) Subclass | (3) Supplier | (4) Catalogue No. | (5) Type | (6) Quantity | (7) Quantity Used/Year | (8) Class | (9) Subclass | (10) Type of Specification | (11) Quantity Required Per 10 Years | (12) Use & Other Information |
| Example 2505 | (4) | NBS | 1093 | Valve Steel, 60 ppm $O_2$ | 3 | 2 | 2503 | (1) | Std. Gas 100 ppm CO | 10 cylinders | Calibration of coal gas analysis instruments, 200 ft. at 2000 psig. |
| 2508 | (6) | self-made | 10 | pH 4.0 Neutral-izing Liquid | 500 ml | 11 | 2513 | (4) | Stainless | 500 g | Accuracy test of chemical analysis for C, Mn, P, S, Si |

## V. PROBLEMS AND SUGGESTIONS

1. Problems: Brief description of your general precision measurement problems (or suggestions).

2. In which way do you want us (K-SRI) to help you? Describe briefly your opinion.

## III.3 BUT IS INDUSTRY AWARE OF ITS DEPENDENCE ON METROLOGY?

Mr. H. L. K. Goonetilleke
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The word "industry" covers a wide spectrum of manufacturing activities, from those producing space satellites to the products of a cottage industry.

Awareness of industry's dependence on metrology varies probably in the same order of magnitude as the difference in the sophistication of the technologies at the two ends of the scale. I propose, therefore, to limit the scope of this paper to the experience of a small country whose industry is not particularly sophisticated and is, for the greater part, of recent vintage.

In Sri Lanka, industry can be divided into three categories, according to a broad time scale, the last war being the watershed.

(a) Prewar: During this period, manufacturing industry was limited to fabricating and assembling special machinery needed for the tea and rubber industries. Otherwise, industry was solely service oriented.

(b) War: A number of special industrial projects were started to produce materials needed for the rubber industry, e.g., acetic acid, or for the manufacture of consumer goods. A few of these continued to exist for a short period after the war, and still fewer now survive with new plants and equipment.

(c) Postwar: With the escalation of prices of industrial goods, which were not matched by corresponding increases in the prices of primary raw materials, industries for the manufacture of glass, cement, mild steel wire, tires, etc., have been established. Their products are mainly for the local market.

It must be said quite frankly that no thought seems to have been given to metrology at any one of these stages. At the most, if any product had to be weighed, a token nod may have been given to the requirements for periodical servicing of the weighing machine, but even that only perfunctorily. Even in the last phase, where most of the investment has been by the State, there have been no demands from industry for facilities to check or improve its measurement capabilities, although there were consultants in the form of internationally known firms involved in both design and execution.

The failure on the Sri Lanka side could be to some extent attributed to the fact that no metrology service existed until the Weights and Measures Division started operating in a small way in 1955, and metrology really began to be considered as a necessary tool in the

technological growth of the country only after 1969. Its practical implementation took a few more years. It was the onset of the metrication program and the consequent expansion of the Weights and Measures Division which enabled the setting up of some of these needed facilities.

The failure on the other hand of the foreign consultants to provide some basic calibration system within a particular project is less understandable. Unless, of course, industry whether big or small has the same blind spot. It might well be that for both groups awareness of the need for metrology is confined only to providing some gages and measuring instruments with the belief that gages remain accurate for all time, and that the indications of a self-reading measuring instrument cannot be questioned.

To the question "Who needs metrology in industry?" the answer is everyone at some point or other whether big or small. The question that follows is not so easy to answer, i.e., "How much metrology?" (in the sense of how fine is the measurement accuracy desired). Then we face another question "What is the cost and what kind of measurement does the product actually need?" The next question is "Who is to provide it?" The answer is, logically, the Government. But how much investment is needed to provide this facility? Hence, a considerable amount of balancing on a seesaw has to be done. Lastly, there is the question "How does one get these ideas across to industry?"--particularly the small and medium units who probably need it most. Unlike in the field of commercial metrology, the service is purely voluntary, and it is very difficult to get the horse to water, let alone coax it to drink.

I propose in this short paper to put down a few ideas. They are at this stage purely germinal, and although based on conditions in Sri Lanka, are at the moment of writing a purely personal viewpoint.

## How to Provide a Metrology Service for Small and Medium Industry

There are a few assumptions made. These are:

1. That the Government currently provides a service of some kind, to test commercial weights and measures, and that there are reasonably equipped weights and measures offices spread throughout the country.

2. That there are government or semi-governmental institutes which have some metrological equipment in use.

3. That most of the industrial units do not have their own tool rooms because of the lack of capital and expertise.

This scheme depends upon the setting up of a network of adequately equipped metrology centers in places which require them. These centers could be extensions of the weights and measures offices, or of a governmental or a quasi-governmental institute, or even of a separate entity especially set up for any new industrial complex. The equipment in a metrology center should be oriented to the needs of industry in that particular area. It should be able to calibrate simple gages like micrometer screw gages, to measure go and no-go gages, to test for hardness, and to test thermometers and thermocouples in the range up to 1000°C, etc.

The metrology center should primarily be a service center for industry in the region in very much the same way that a weights and measures office is a "service center" for trade, or more appropriately, the relationship between a metrology center and industry should be the same as the relationship between an agricultural extension center and the farmer.

This, one might say, is merely providing the water trough, but to bring the horse to it and to make it drink is an entirely different matter. To achieve this, one has to have recourse to one of two methods, namely, the use of incentives or the use of statutes, as in the case of weights and measures laws.

I have referred to the agricultural extension services as models that have to be looked into. Extension services provide incentives and are intended to be involved in farming practices with the aim of encouraging and improving agricultural practices so as to improve productivity. The ultimate aim of the proposed industrial metrology centers is better and more products. Hence, similar techniques could be used.

The principle of an agricultural extension center is that it does not wait for the farmer to call, but goes out to the farmer. The shop floor of an industrial metrology center should include all the shop floors of the industries that it serves. Moreover, it should not be uni-directional, information flowing in one direction only. It is important that there be a feedback from industry so that assessments can be made of the measurement capabilities of the metrology center.

Simple calibration audit shemes, such as the circulation of test pieces for measurement of dimensions to all the industries serviced by the metrology center, would help to evaluate the skill and the accuracies of the methods of measurement, as well as that of the gages used. In additon to these techniques, seminars on quality assurance methods and control chart systems could be introduced to industry through these centers. If further incentives are given in the form of tax rebates, etc., they should be made conditional on the use of the facilities of the metrology centers and on participation in the audit schemes.

The second method, the use of statutory powers, as in the case of commercial metrology, is one which has built into itself considerable obstacles. A very obvious one is that to fail to comply with directives is to call for legal action. In the case of trade metrology, there is the other party to the transaction that has to be protected. Here there is no such person because the aim is to prevent waste and loss, and though there is an ultimate purchaser of the product who will benefit if there is little waste, it is the country at large that derives the benefit. It is in the writer's view, therefore, that this is a path which is tortuous and winding.

This article is rather sketchy, and that is primarily because the experience in Sri Lanka of providing metrology services to industry is very limited. The exercise is just beginning, and the questions raised in the first part of the paper are ones that are being mulled over. The second part of the paper contains a somewhat rudimentary scheme which is offered for discussion in the hope that it will generate better and more coherent answers to the question "How to make them drink?"

## III.4 THE NATIONAL METROLOGY AND CALIBRATION SERVICE FOR INDUSTRY IN THAILAND

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Bangkok, Thailand

### A. INTRODUCTION

The economic development of Thailand has mainly been dependent on agriculture and industry. During the Third Economic and Social Development Plan period from 1972 to 1976, the Gross Domestic Product grew at an annual rate of 612 percent, the manufacturing production at 816 percent, and the exports at 14.6 percent. The population growth rate declined from 3.1 to 2.6 percent during that period. However, the country has encountered a number of serious deficiencies in the pattern of its development. A dual economy has emerged. The modern sector has accounted for much of the growth achieved, but it has also led to some unhealthy and disruptive problems, such as a wide disparity in income and standard of living among the rural as compared with the urban populations, the unemployment and migration of rural population into the cities, the perpetuation of the gap between the rich and poor which tends to lead to social disturbance and political instability, and finally, the depletion of natural resources and deterioration of the environment.

In the Fourth Economic and Social Development Plan ranging from 1977 to 1981, the Government has stressed the utilization of Science and Technology (S & T) in various economic sectors, especially agriculture, industrialization, mineral resources, and energy development.

The S & T work plan for the industry sector was outlined as follows:

1. To transfer technology for the best benefit of industrialization.

2. To improve the quality of personnel and workers by training and education and to promote quality control in industry.

3. To accelerate the process of issuance of patents and thereby to welcome innovations in technology.

4. To improve the policy for investment promotion.

5. To promote the Thai standardization system involving product standards, standard reference materials and methods, calibration and maintenance of scientific equipment, and the service for quality certification.

In order to accomplish the target for standardization, the following projects are emphasized:

1. A center for standardization and calibration of scientific equipment must be initiated using reference standards and standard reference materials.

2. The standardization program for industrial and agricultural products must be accelerated.

3. The central laboratory in a government organization for analysis and testing of industrial and agricultural products must be improved for effectiveness of service to the country.

4. Education and training of personnel for repair and maintenance service of scientific and technical equipment should be expanded to be able to produce enough personnel for this purpose.

B. <u>Science and Technology Service at the Department of Science</u>

The Department of Science is one of the six departments in the Ministry of Industry. It was first set up in 1891 as a small unit in the Royal Department of Mines and Geology and in 1902 was transferred to the Royal Mint as an assay office. In 1918, existing units dealing with science and technology were combined into one organization called the Government Laboratory which belonged to the Ministry of Finance. This organization became the Department of Science in 1933, and in 1945 it was transferred to the Ministry of Industry. Through the long history till the present, the Department of Science has served Government and private organizations, industry, and the public, providing scientific and technical services. At the present time, as shown in the organization chart, there are six divisions together with six other offices operated under the Department of Science. The operational work and staff of the Department as a whole are supported by the Government of Thailand.

As the National Laboratory, the Department of Science has been providing the following services:

1. Chemical, physical, and biological analyses.

2. Metrology and calibration of scientific instruments and testing machines.

3. Testing of raw materials and finished products.

4. Service for quality certification and quality control.

5. Industrial standardization.

6. Research and study on industrial techniques, equipment, and process development.

7. Study on quality control for quality certification.

8. Training in applied science and specific topics.

9. Consulting and trouble-shooting services for industry.

10. Research and development works on the utilization of the nation's natural resources and the treatment process of industrial and agricultural wastes.

The Department of Science is a neutral body acting as a central laboratory and acts as a reference laboratory with respect to reliability and terms of reference in Science and Technology.

The staff and personnel involved in the service at the present include 273 scientists and engineers, 40 technicians, and 333 office personnel. Among the scientists and engineers, there are 55 Ph.D.'s and 39 M.S.'s; the rest hold B.S. degrees.

The analytical services performed during January to June 1978 are shown in the following table. The number of samples and number of items tested are listed.

| Type of Analysis | January No. of Sample/Item Test | February No. of Sample/Item Test | March No. of Sample/Item Test | April No. of Sample/Item Test | May No. of Sample/Item Test | June No. of Sample/Item Test |
|---|---|---|---|---|---|---|
| Biological | 226/1278 | 291/2151 | 245/1839 | 219/1888 | 223/3381 | 240/2012 |
| Chemical | 273/1800 | 369/3531 | 281/1831 | 266/1533 | 448/2193 | 492/3604 |
| Research | 22/110 | 48/191 | 43/184 | 24/113 | 69/188 | 23/126 |
| Physics and Engineering | 109/2944 | 156/1721 | 216/1562 | 225/2004 | 249/2140 | 226/2293 |
| Ceramics | 71/146 | 16/70 | 46/96 | 26/97 | 42/231 | 42/208 |

There are many research projects being carried out at present; they include 17 in food and food preservation, 8 in material and industrial processes, one in solar energy application, and 3 in environmental problems. Examples of specific tasks are quality improvement of plastic and rubber products, a dry process for cassava flour production, ceramic processing, pulp and paper technology, and solar energy for distilled water production.

C. Reference Materials and Calibration

In 1973 the National Bureau of Standards with the cooperation of the AID office at Bangkok carried out a Standardization and Metrology Survey in Thailand. The survey team recommended the establishment of a Metrology and Calibration Center. The Department of Science has

established such a Metrology and Calibration Service Project in the Division of Physics and Engineering. The objectives of this project are as follows:

1. To provide calibration services to Government, industry, and the public.

2. To seek for and to prepare reference materials for intercalibrations of scientific instruments among various scientific laboratories.

At present, the Department of Science has available a number of primary standard weights and measures and calibration instruments. These primary standards are used for calibration of secondary working tools. The primary standards available are:

| | |
|---|---|
| Length and mechanical property measurement, set | 36 |
| Standard weight and balance, set | 2 |
| Electricity standard meters, set | 23 |
| Light measuring meters, set | 6 |
| Sound measuring meter, set | 1 |
| Volume, heat, and temperature meters, set | 10 |

Equipment calibrations performed during the past two years are:

| | |
|---|---|
| January - December 1977 | 65 items |
| January - July 1978 | 80 items |

D. Intercalibration of Mercury Analyzer and Method for Mercury Analysis

It has been known throughout the world that mercury contamination in the environment has created a big problem for the public health and welfare. In Thailand there has been research and study on mercury pollution in several laboratories. One problem encountered by the research is the lack of agreement between laboratories concerned in the mercury analyses. The Department of Science has proposed a program for intercalibration for the analysis of mercury in marine pollution by using synthetic sea water as reference sample.

The synthetic sea water was prepared according to the formulae of Lyman and Fleming* and a known amount of mercury was introduced and estimated to be $1.5 \pm 0.3 \mu g/\ell$. Two sets of such reference samples prepared under the same conditions but on different dates were sent to various laboratories for mercury analysis. The samples were analyzed during the specified period of time by different instruments, such as atomic absorption using a mercury analyzer kit, a mercury analyzer by flameless atomic absorption, and using dithizone with a

*Harold Ulrik Sverdrup, Martin Wiggo Johnson, and Howell Fleming, The Oceans, Their Physics, Chemistry, and General Biology, Prentice-Hall, Inc., 1942, 1087 pages.

spectrophotometer. The analysis results for mercury content of the reference sample as plotted on the graph paper (Figure III.4.2) showed the differences ranging from 0.1μg/ℓ to 2.2μg/ℓ with an average of 0.85μg/ℓ in the first set and from 0.105μg/ℓ to 3.5μg/ℓ with an average of 1.95μg/ℓ in the second set. The standard deviations in the 2 sets of results are 0.77μg/ℓ and 1.29μg/ℓ respectively.

When the known amount of mercury in the synthetic sea water is compared with the results of analyses, it appeared that the grand average from both sets, 1.40, closely approximates the known value.

The results showed that every method used was as sensitive as the other within the range of mercury content analyzed. However, the scattering of mercury concentration obtained by each laboratory seemed to be very large even though each laboratory had calibrated its own instrument with a reliable standard. Further investigation found that the discrepancy in results was due largely to the difference in concentration of mercury content in the standard sample used for calibration. Some laboratories used a high concentration and some used a lower concentration of the standard solution for the calibration of their instruments. It was therefore suggested that the standard solution used for calibration should be of a similar nature and concentration as the sample to be analyzed.

E. Future Work Plan

Metrology and calibration needs, especially by industry in Thailand, have been increasing in number and variety. The indication can be seen from the number of requests for calibration services this year which accounts for more than a 20 percent increase within 7 months compared to the number of requests last year. This increase may be attributed to several factors, such as:

1. There has been an increase in the number of industrial factories in recent years. Factories usually require analysis and testing of their own raw material and products. The equipments used in the factories once in a while need good maintenance and calibration.

   With respect to promotion of local industry, the Government has a stated policy that the Government organizations which want to buy any product in the market are allowed to buy a local product with a 15 percent higher price than the corresponding imported product if the local one is approved by the Government agency. Such approval is either by a standards mark or by a quality certificate.

2. Both the standard mark and the quality certificate programs being carried out at the Department of Science have indirectly influenced industries to perform their own tests of materials and products as much as possible. The standard

or TISI mark is issued after the Thai Industrial Standards Institute requirements are met, such as for a regular check of the finished products being in conformity with the specifications. It is, therefore, necessary for the factory to have its own testing equipment, and such equipment needs regular calibration.

The quality certificate is issued for a product which meets international standards or any foreign standard. This program requires a sampling test and reliable quality control system in the producing industry. Only well-calibrated equipment can be accepted for satisfactory quality control.

3. The vendor-purchaser agreement in today's business usually uses test certificates as a reference for ordering goods. The testing facilities are becoming more and more necessary, and such facilities would not be competent without good maintenance and calibration.

4. As the Government emphasizes the application of Science and Technology in the forthcoming National Development Plan, there will be an increasing amount of research both in the Government and the private sector. More funds will be spent on equipment and tools for which calibration service will be most needed.

   As far as metrology and calibration are concerned, it is felt to be in the best interest of the country for the primary standard and calibration service to be centralized rather than scattered in various laboratories. However, the secondary and working standards and reference materials should be distributed throughout for routine check in every laboratory concerned.

For the above reasons, the Department of Science which acts as a center for scientific and technical reference has extended its present capacity to be able to serve industry and other laboratories in instrument calibration. In doing so, more standard reference materials and standard equipment are necessary. More government funding will be applied, and foreign assistance and collaboration will be sought. It is hoped that some assistance and cooperation can be received from highly developed nations, such as the United States and Japan, as well as the most rapidly developing countries, such as Korea, India, Singapore, etc.

It is suggested in this seminar that all countries of this region should initiate a collaboration network for exchanging of experts, standard reference materials, and calibration technology. This network can be established by the assistance of advanced countries, especially the United States, Japan, and Australia.

## ORGANIZATION CHART OF DEPARTMENT OF SCIENCE

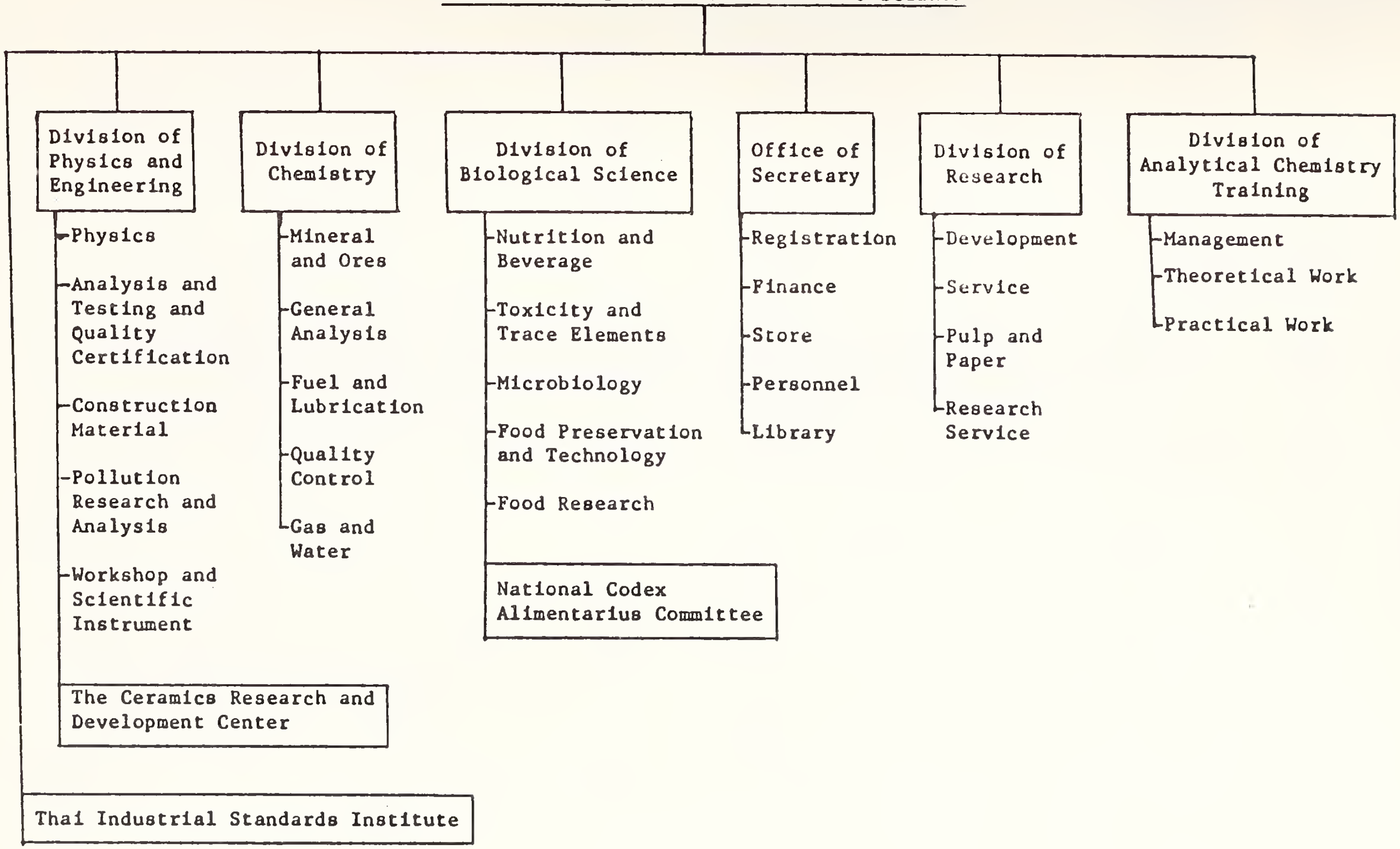


Figure III.4.1

SCATTERING OF ANALYSIS RESULTS OF
HG CONTENT IN SYNTHETIC SEA WATER

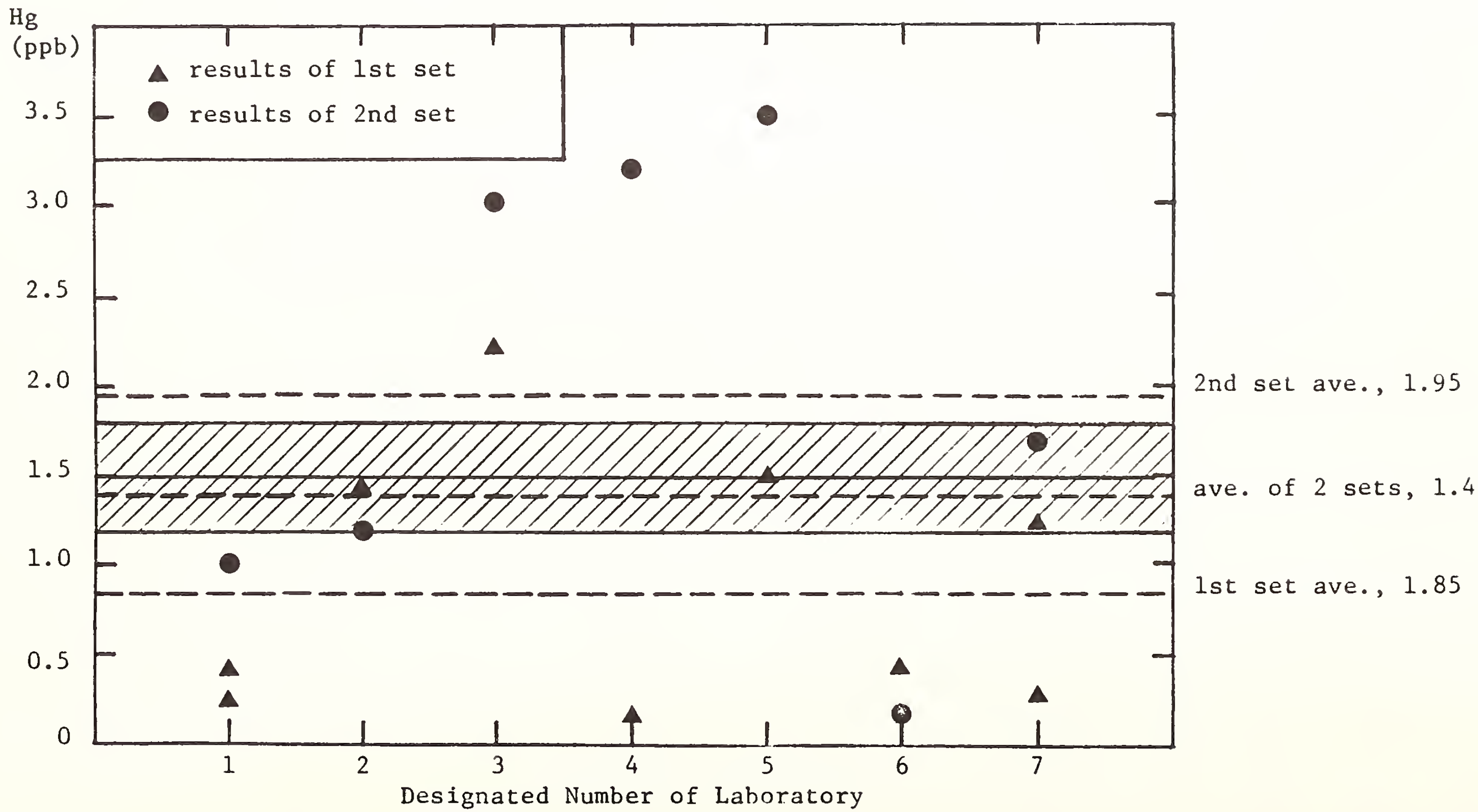


Figure III.4.2

## DISCUSSION ON SESSION I

Rapporteurs: Dr. Nak Sam Chung, Dr. Chul Koo Kim, Dr. Jae Chang Lee, Dr. Jong Chul Park, and Dr. Choonghi Rhee

In the Concluding Session, the participants debated further the three questions that were introduced successively during the earlier sessions.

I. Are we (the metrologists) aware of the need for (usefulness of) metrology?

Dr. Vashrangsi (Discussion Leader):

I think that debate on this topic need not be long because yesterday every speaker has shown clearly that he is convinced that metrology is highly important in science and technology. If we look at the history of development of science and technology, we will find that every new discovery comes from good and precise measurement. Science is more or less basic knowledge, and technology is an applied science. Thus, they have the same basic foundation. So, most of our speakers have come to an agreement that we all need metrology. This is my viewpoint. Other members may want to add to it.

Mr. Larkin:

I wish to reemphasize the importance of metrology and regional cooperation in metrology.

Mr. Peiser:

Let me go back to the question that I was asked yesterday. In what way do metrologists differ from ordinary scientists? Metrology in science and technology is so very basic, so as I have pointed out, it is necessary for scientists and engineers to be metrologists to some extent. I call them at least amateur metrologists. However, there are big differences between amateurs and professionals. The professional metrologist looks at the experimental design and its statistics, he searches for errors and eliminates all he can within reasonable effort, and he estimates his uncertainty with care and caution. I do not find the question we are debating trivial. In fact I know many metrologists who would question whether their measurement skills are applicable to much of science or any technology. I believe they are wrong.

Dr. Lim:

I think we agree that big industries need calibration and a standards laboratory and so on. I wonder myself whether this is true for small- and medium-sized industries.

Dr. Blevin:

I can respond affirmatively by an example. Australia is exporting semi-processed cheese to Japan, for which that country enforces a very tight tolerance. Many of the dairy processing factories had not been able to meet that tolerance. The Australian Dairy Corporation, which is government supported, by very constant efforts, helped them to set up proper testing laboratories in the factories where precise, compatible measurements can now be made. With these, Australian small-scale industries were able to attain the quality to meet Japanese specifications.

Dr. Probine:

Metrology has made certain technical advances possible. Let me give you an example. In the PAL system of television, the color burst frequency from the T.V. station locks the oscillator in the set in your home to a frequency that is accurate to at least 1 part in $10^8$. If the frequency departs from this, the color does not remain "true." In actual practice, the color burst frequency is controlled to about 1 part in $10^{11}$ for most of the time, using a rubidium vapor oscillator. It is not so very long ago that this level of accuracy could not have been obtained in even the great national standards laboratories. Today it is commonplace--the result of developments in the field of precision measurement.

Mr. Goonetilleke:

In developing countries, awareness of metrology in industry is not adequate. We should find out what kind of technology is needed in each country and develop metrology suitable for the situation. Only then will we as metrologists have an awareness of the needs, and that will make our advocacy convincing.

Dr. Verma:

Metrology is needed to manufacture export products which are under quality control.

DISCUSSION ON SESSION II

II. Is industry aware of its dependence on metrology?

Dr. Probine (Discussion Leader):

According to the presentation of Dr. W. Jung, a recent industrial survey conducted in Korea showed that, among the instruments covered, the precision of 47 percent of the instruments was unknown, and 84 percent were uncalibrated. Our colleagues in Pakistan have had a somewhat similar experience.

Does this kind of situation not suggest that industry is not aware of its need for precision measurement (metrology)?

It would be helpful, before we open this topic for general discussion, to hear from Mr. Kuhns, who is the only representative from industry here today. Mr. Kuhns is with Hughes Aircraft Company and is well qualified to comment. He had agreed to have his prepared paper postponed from the main Session II to this Discussion.

Mr. Kuhns:

It is my very great pleasure to address this gathering today on the question of whether or not industry is aware of its dependence upon metrology. I am very fortunate to be associated with a company whose products span a wide range of complex technologies and whose research keeps it constantly at the frontiers of the most advanced technologies. We, therefore, maintain not only a high level of awareness of our dependence upon metrology and standardization but must continually improve our measurement systems and develop new standards where none exist.

I believe that the awareness of industry of its dependece on metrology is in direct correlation to the level of the technology involved. That is, the more complicated and sophisticated technologies tend to create a greater need for control of processes and materials. This in turn requires more stringent measurements providing inherently a better understanding and awareness of the need for metrology.

The development of an awareness of metrology and the need for it begins as a society or country starts to grow away from an agrarian or artisan-type economy toward an economy which generates products, not only for internal use but for export. Export markets are highly competitive and require established levels of quality. Entry into such markets establishes the criteria for a measurement system which will not only demonstrate the quality of the product but which will ensure confidence in the product within the marketplace.

Once the acceptance of the products in the export market is firm and industry begins to expand in the scientific and technological sense, the side benefits of a well-founded metrology program become self-evident. Such benefits include constantly improving products, a reduction in material waste, and more efficient production methods.

As the market grows, the continuing development of products leads to more complex and difficult requirements in order to assure the quality of the end item. This, then, requires a wider and more complete measurement program. With the growth of products both in scope and complexity comes a greater awareness of industry of its dependence upon metrology.

Perhaps one of the most outstanding examples of industrial faith in metrology and standardization is the United States Space Program. We assemble large and tremendously complicated vehicles to propel either man or a satellite into space. The number of components needed runs into the millions, and almost all are bought from the lowest bidder. Thus the total mission may be as equally dependent upon an inexpensive fastener as a complex gyroscope. Yet such is our faith and awareness of the excellence of our system of standardization and measurement that components are accepted from a multitude of manufacturers and assembled into a launchable vehicle.

I do not mean to imply from the foregoing that industrial awareness of its dependence upon metrology and standardization is an automatic or even smooth process. In fact, it is quite the opposite, a drawn out erratic growth which only develops through a continuing process of education and matures as the benefits become self-evident.

One could, in fact, equate the industry/metrology relationship to that of a patient/doctor relationship. In the normal day-to-day activities, the patient may be aware of his dependency upon the doctor but not on a conscious level. It is only during times of great stress or when the doctor has restored his well-being that the patient recognizes his dependency and becomes truly appreciative of the benefits which may result from the relationship. Similarly, an industrial awareness of its dependency upon metrology is probably prevalent in most industries but is rarely given attention during routine operations. It is essential, therefore, that a program of stimulation of interest and education in metrology be maintained to insure continued awareness of the needs of metrology throughout a national industrialization process.

Dr. Probine:

I visited the Coventry Tool & Gage Company in England some years ago, and I was told that, at that time, the person responsible for quality control reported directly to the Managing Director. For this company, quality control was so important to its reputation that the chief

executive took a personal interest in this kind of decision. There are, therefore, firms that do understand the importance of metrology.

I would now like to ask Dr. Takata to comment on industrial attitudes in Japan.

Dr. Takata:

In Japan many industries are aware of the need for metrology. However, in many industries there is still a lack of an adequate understanding of metrology. The Government is now trying to establish a national metrology system.

Dr. Probine:

Dr. Kunzmann will present views from West Germany.

Dr. Kunzmann:

In West Germany, small and medium industries are well aware of the need for metrology because the export market is expanding. However, there is another more important reason for this acceptance. The cost of industrial production in our Federal Republic of Germany has become very high in comparison with that in other industrialized countries. Therefore, in international markets, our most important arguments in support of products "made in W-Germany" are high quality and long life time. Consequently, our industry has become aware of the need for metrology, because it is the basis of all well organized quality assurance systems.

The Physikalisch-Technische Bundesanstalt, the national standards laboratory, provides primary standards, and firms like Siemens, for example, have their own standard laboratories to maintain good quality control in production. We all believe "made in W-Germany" should mean that something is well made and is likely to have a long life.

Dr. Chun:

In the management of quality control systems, we can recognize three different stages, the initial developing stage wherein the need for metrology is demonstrated, the design stage in which the detailed technical needs and economics are elaborated, and the operational stage for quality control in the production line and for inspection of the final products. Each stage has to be adapted appropriately to the level of development and the industrial activity to which it is applied. A suitable attribute must be selected for the measurement process.

Dr. Kunzmann:

Metrology, whether in developed or underdeveloped countries, is equally important, and it needs to be applied in agriculture and science, as in high technology. In science, metrology is important because one's experimental results become credible only when the measurement is correctly taken. Metrology, in every phase of production, has an important role, which has a direct relationship to the quality control system.

Mr. Goonetilleke:

Quality control in industries often does not involve the assignment of numerical values. Measurement technology, therefore, is only a part of quality control. Quality control, regardless of the process used, is always concerned with the final products.

Mr. Kuhns:

The quality control function in my company involves the highest level of management. Relevant reports go to the chief executive officer and members of the board of directors who have some direct input on how the control operates.

Dr. Choi:

The Government itself is responsible for instilling an awareness in Korean industry of the importance of metrology. The nationwide quality control campaign emphasizes the need for metrology as I have described in my paper yesterday. Our Government is now concentrating on education and training of the people engaged in quality control, from the top management to the workers in the assembly line. This year our goal is to conduct training programs for 13,000 people.

Dr. Probine:

This kind of campaign is important, and many groups can contribute directly or indirectly. Managers educated to appreciate the importance of good quality control have a role to play. Customers can also insist on good quality control in the terms of a contract. For example, military specifications are typically very tight, and firms that engage in this field must meet high quality standards. Manufacturing for aircraft companies requires the same high standards. In New Zealand, we find that the operations of the Testing Laboratory Registration Council, and its laboratory accreditation scheme, are having a beneficial effect in increasing industries' appreciation of good measurement practice.

I cannot emphasize too strongly that, in my view, top management has the primary responsibility for ensuring that appropriate quality

assurance procedures are used, and that such programs are backed by sound measurement practice.

## DISCUSSION ON SESSION III

III. Who is aware that a national capability in metrology is essential to industrial development?

Dr. Blevin (Discussion Leader):

Is it important to have national capability in metrology? We are going to consider this question from two viewpoints; firstly from that of the need preferences for the internal application of metrology within an individual country, and secondly from that of external collaboration with other countries. I propose that, for the first 15 minutes or so, we restrict our remarks to the importance of a national center for internal reasons in a particular country. Several participants, I know, wonder if Dr. Verma will agree to comment on this important question.

Dr. Verma:

The awareness of metrology in industry is gradually picking up in India. Now we have sophisticated industry such as the electronics industry. Equipment must be calibrated. During the last few years, electronic and electrical industries have felt the need for accurate measurement in ampere, volt frequency, etc. Now we really understand the usefulness of metrology, and in consequence we enjoy wide-ranging benefits. For instance, the value of mica exported from India was greatly increased by reliable measurements by which the high-quality material could be identified and reliably offered to world trade. The more a country progresses in industry, the more it realizes the importance of measurement technology. There is a direct correlation between technology and awareness of the need for metrology.

Dr. Blevin:

I wonder if I may ask one more question of you, taking the electronics industry as an example. Is it necessary to have a metrology facility in advance of the demand by industry?

Dr. Verma:

Yes. For all countries, metrology should be one step ahead of the need in industry. This is true not only in time, but also for the accuracy achieved. We have to have a capability one order of magnitude better than industry.

Dr. Blevin:

I think we can choose a national capability in metrology with one centralized standardization authority, or we can think in terms of having a scattered network of calibration and technology facilities

operating in widely different fields, but with a monitored compatibility. I think all industrialized countries have a similar type of central laboratory to realize high accuracies. But there are different solutions at lower levels of the metrology organization. I would like to ask the U.S. representative to comment in this respect; how is it done below the NBS level?

Mr. Peiser:

In some particular fields of metrology, you will have to have just one central capability. Let me take an unusual example: determination of atomic weight is important in world trade. The current accuracy level for the germanium atomic weight is only about 3 or 4 parts in $10^4$. When we talk about a consignment of a million dollars, this kind of error can amount to several hundred dollars. Therefore, a national arbitrator has to be recognized. I do not know whether this answers your question.

Mr. Walleigh:

I thought Dr. Blevin asked about the secondary laboratory system in the U.S.A.

Dr. Blevin:

Mr. Peiser, you certainly answered some of my question, but I would still like to hear about the secondary organization in the U.S.A.

Mr. Walleigh:

We do not have what one may call one secondary system. However, every major company, such as Leeds and Northrup, DuPont, Ford, and Hughes Aircraft, aims to have a capability in metrology appropriate to its own needs. In addition, we at NBS perform about $5 million worth in calibration services each year, although this is less than 5 percent of our total workload. In the past 25 to 30 years, NBS has sought ways to reduce its routine calibration workload. To this end, we have developed a great many Standard Reference Materials (SRM's) which are highly characterized materials which can be used to calibrate equipment or control production. The SRM method has been very effective. We also give and participate in seminars and symposia on subjects related to calibration. For example, during the past six or seven years, we have become aware of the need for improving the calibration of clinical laboratory equipment, and we have emphasized this in some of our recent seminars.

Control of weights and measures is a function of State Governments, not NBS. We do advise the states technically through the National Conference on Weights and Measures (NCWM). We also have other organizations which stress metrological accuracy, such as the National Conference of Standards Laboratories. On the matter of accreditation

of laboratories, we in the United States are trying to study and to learn from the experiences of other countries, such as New Zealand and Australia.

Dr. Chun:

I would like to point out two instances for which a single national capability is needed in metrology. They have a direct relationship to the very existence of K-SRI. For evaluating solar collector equipment, each company uses a different method, so that customers are confused. One central body should lay down one method to be used by all. Similarly, when I worked at Brookhaven National Laboratory, I faced many difficult problems with fluid flow measurement. In short, when one has a measurement problem, such as in temperature, pressure, etc., one goes to a central authority such as NBS and obtains a solution accepted by all and thus saves a lot of time and money.

Through measurement, K-SRI has the opportunity to fill that function in Korea, and at the same time, reach down to industry and lead the way, and in a great technological advance, to give rational answers why technical selections were made, how to obtain zero defects and quality assurance, how to estimate probability of breakdown, and how to characterize materials. Certainly NBS is in all these fields as a national leadership organization.

Dr. Blevin:

A national laboratory need not necessarily realize all high precision standards. Has anyone present an opinion against the concept of one National Center for Metrology?

Dr. Jung:

I am really speaking in favor of a metrology center. A National Center for Metrology should look to the future, and promote certainly: (a) quality control and (b) advancement of technology.

The opportunity is even more wide-ranging. Industrial advancement needs technology transfer from advanced countries. Some national organization should promote that. The Metrology Center has the necessary capability and know-how. Dr. Verma mentioned his experience in India in the production of mica—a fine achievement for metrology.

For a National Center it is relatively easy to copy technology exactly. But we should know why some specifications are made. In this way the National Metrology Center will work for technological advancement through a real understanding. We need a National Center to push industries. Mr. Larkin will agree on this point. What we want is zero defect production. We like to specify how equipment will perform. We like to estimate when it will break down. Not only the performance of the machines is important, but also the

characterization measurements on material are important. As Dr. Kuhns mentioned in his case of Hughes Aircraft, we need also new types of metrology; NBS is already shifting effort from mass, length, etc., the so-called traditional metrology, to new applications where the basic philosophy of good measurement is equally relevant.

Dr. Blevin:

Dr. Jung, you really underscored the case for a National Center of Metrology. Let us thus conclude discussion of the internal reasons and turn to the external reasons for a National Center. For example, we at the National Measurement Laboratory of Australia feel that we have an important responsibility to adhere to the fully international focus in metrology, the International Bureau of Weights and Measures. We are also aware that highly industrialized countries, such as Japan, meet quite regularly with their trading partners. A different forum might be needed for regional collaboration. Let us discuss such a possibility. First, K-SRI would like to make some suggestions. Then, let us hear Dr. Kunzmann's experience with a European Organization. We will then continue with a proposal by Dr. Probine, and finally turn to a general discussion.

Now Dr. J. C. Lee will introduce the K-SRI suggestion.

Dr. Lee:

Regional metrology seminars held in the Pacific and Asian regions have brought together many institutions and have proved to be very useful not only in fostering friendship among metrologists but also in sharing national experiences in standards and metrology. It is significant that we here consider the value and advantages of metrology gatherings.

Firstly, each country, whether already developed or still in the process of development, has different needs, resources, and attitudes toward standards and metrology. It would be a very expensive proposition for just a single country to provide and develop a total system of standards and metrology. Because metrology is universal rather than national in nature, the sharing of experiences, of technical know-how, and of information developed and achieved by a neighboring country could mean a very significant saving in time and resources.

Secondly, although we want to know what needs and capabilities of human and hardware resources are available in a neighboring country, that information is difficult to obtain without an organized system of conference contacts. We need to comprehend the methods by which standards and metrological activities are handled in each country.

Lastly, the friendship to be established during regional metrology conferences could be a means of making first contacts on an informal

basis whenever one needs to know special matters in standards and metrology. Temporary assignments of specialists to neighboring countries for teaching, learning, or comparison between certain national physical standards would inevitably be discussed at such conferences and perhaps be implemented at a later time when found to be of mutual benefit.

Aside from these merits to be derived from gathering at a Regional Conference for discussing topics of common interest, meetings like the one hereby proposed would certainly give all of us a feeling of continuity. It definitely will be worthwhile to convene conferences on a regular basis. The gatherings could be informal and personal, rather than institutional. They must be non-political. They should encourage everyone interested in standards and metrology in the Pacific and Asian region.

Therefore, we suggest that exploratory discussions be held at this time. Alternatively, we could form a provisional committee to study the creation of a regional metrology conference in the Pacific and Asian countries. We also submit that this conference could be named "Pacific and Asian Conference on Metrology" or PACMET.

The proposed objectives of PACMET should be to:

1. Organize general meetings rotated among member countries at least once every two years.

2. Promote consultation and advisory services.

3. Arrange exchange programs.

4. Organize study tours.

5. Promote continuing education programs.

6. Organize seminars and other special topic meetings.

7. Sponsor joint projects for research and development in fields where a common interest and a need is known to exist.

Dr. Blevin:

K-SRI, through Dr. Lee, has made an interesting proposal. I believe that the mode of cooperation between national metrology centers should be part of our discussion, and I would like to invite Dr. Kunzmann to speak about the "Western European Metrology Club."

Dr. Kunzmann:

On behalf of PTB, I bring greetings to Dr. Kim and to all participants.

It is very useful to exchange experiences among different countries. For this purpose, in Europe the Western European Metrology Club (WEMC) has been formed. It is concerned not only with general problems in metrology but also with the exchange of metrological procedures. Audit programs between laboratories in industry as well as between national laboratories are stimulated and organized.

I think it was a really good idea for K-SRI to begin not only internal work in the Korean community but also at the same time to start communication with other countries.

I wish you a very successful future.

Dr. Blevin:

Thank you very much, Dr. Kunzmann. Are there any questions for Dr. Kunzmann specific to the European experiences? I have one question. Could you please clarify what is the membership of the Western European Metrology Club? Does it correspond exactly to the Economic Community of Europe?

Dr. Kunzmann:

No, not quite. Austria and Norway, for instance, do not belong to the ECE. These nations are members of the Club with ECE member countries.

Dr. Ghani:

Do the member countries contribute financially to the activities?

Dr. Kunzmann:

No, they do not. The Club does not require any sizable fund.

Dr. Blevin:

Let us ask Dr. Probine to tell us his thoughts.

Dr. Probine:

There has already been some progress in arranging for a greater measure of cooperation in the Asian/Pacific area. A program has been initiated by the Commonwealth Science Council which is aimed at surveying facilities held by Commonwealth countries in the area as a prelude to arranging a greater degree of mutual cooperation in calibration and training. A regional directory of calibration facilities is being prepared. It has been suggested that this program be extended to include non-Commonwealth countries. I personally support this view.

I, therefore, welcome the view put forward by Korea for a greater measure of regional cooperation in metrology. I think we all have much to gain by this kind of cooperation.

Dr. Takata:

A seminar on international cooperation in metrology was conducted in Japan by the Japan International Cooperation Agency (JICA). Many Asian countries, like Thailand, India, Malaysia, Indonesia, and so on, participated. The seminar, I think, was very effective in furthering cooperation among Asian countries. In reference to Dr. Lee's proposal, I hope, from now, the Japanese experience will be taken into consideration. Dr. Verma, Dr. C. K. Kim, Mr. Goonetilleke, and I participated in an International Symposium on Metrology and Measurement Standards in Developing Countries, ISMET 78, held in Tokyo from the 13th to the 18th of March, 1978, under the auspices of the Government of Japan. The Symposium participants discussed the present status of development, maintenance and dissemination of measurement standards in each country, and future schemes for systems and equipment as well as desirable ways of international cooperation in that field. At the closing session, a summary of the consensus developed during the Symposium was adopted, of which the following is an extract:

> "...Delegates from 15 different developing countries participated in the Symposium. They reported the present state of measurement standards and metrological services in their countries and highlighted the problems being encountered in their respective countries.
>
> "The importance of measurement standards and metrological services for the development of industry and the economy of the countries was emphasized. Several delegates brought out the urgent need for the establishment and improvement of their facilities and systems for metrological standards and services.
>
> "At the same time, the delegates recognized their problems of finance, education and training of technical staff in this field and agreed to promote the exchange of information in metrology, mutual comparison of measurement standards, and exchange of technical staff....
>
> "In addition to the country reports, some special lectures by Japanese specialists were given. These included lectures on the training and personality of metrological engineers, length standards, mass and force standards, temperature standards, electric and electronic standards, and photometric and radiometric standards...."

Members of the program committee of this Regional Seminar have expressed the opinion that it had been their aim to recognize the regional significance of ISMET 78, to expand the dialogue so started, and to commend the study of the full Proceedings of ISMET 78.

Dr. Blevin:

Thank you, Dr. Takata. Now, Dr. Roxas.

Dr. Roxas:

There seem to be too many groups. I think this cooperation should be carried out under a recognized international body. That is, we should be attached to one central international organization because metrology is international in both its technical and legal aspects.

Dr. Blevin:

I certainly agree with full worldwide international cooperation. However, I think belonging to a regional group is still desirable. The General Conference on Weights and Measures under the Treaty of the Meter is too large for regional cooperation on working-level problems.

Dr. Ghani:

I think it is a very useful idea to have regional cooperation. The U.N. should contribute some funds for this.

Mr. Goonetilleke:

In Sri Lanka the metrology organizations do need financial support from outside, such as from UN agencies.

Dr. Probine:

I would like to make some comments about the regional grouping and the point made by Dr. Roxas. I think the regional groupings will merely stimulate understanding by occasional meetings. They will help us to get to know each other and exchange ideas. Metrology will remain fully international.

Dr. Vashrangsi:

Since metrology is one of the sciences, I think UNESCO is interested in this subject, too. Perhaps we can obtain some contributions from UNESCO.

Dr. Verma:

UNESCO may find it difficult to support regional groupings, but might fund a program for fully international cooperation in metrological activities.

Mr. Goonetilleke:

I agree that there would be some administrative problems in UNESCO's contributing specifically to the Pacific area.

Dr. Lee:

Since we have had enough outside help in metrology in our region, it is about time for us to start our work more actively on our own initiatives. The regional conference we propose would first organize committees for special purposes, and then it will be quite natural to seek the necessary funding from appropriate sources, whether it be from the members or outside agencies.

We should also consider the alternative of designating the proposed organization as a "network" which indicates traceability, too. Nevertheless, the word "conference" may be preferable for our case. At any rate, I do not envision any conflict between this conference and other more fully international organizations. We could utilize their experience and cooperate in many ways.

Dr. Kim:

I strongly support the proposals for regional cooperation and would like to enter into the record information on the 1979 ASCA meeting.

The Association for Science Cooperation in Asia (ASCA) was established in 1970. Its first meeting was held in Manila in 1972. Member countries of ASCA are: Australia, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. ASCA was established because:

1. Of the urgent need for regional cooperation in applications of science and technology to common problems in Asia.

2. Of the need for a close and integrated liaison among the countries in Asia on their individual research and development policies and programs.

3. Within the region, there are skills and resources in science and technology which could be applied to common problems by mutual consent as to priorities and which thus could accelerate the development and economic growth of the region.

At the 6th ASCA meeting which convened in New Zealand from February 23 through March 1, 1978, a resolution was passed that Korea will host the 7th ASCA meeting which is scheduled for May 1979. The Ministry of Science and Technology (MOST) will be the hosting organization.

The first technical session will be at the Korea Institute for Science and Technology, Seoul, May 14-16, 1979, on the topic of commercialization of industrial technology.

The second technical session will be at K-SRI, Daeduk, May 14-16, 1979, on industrial standardization. Topics will include:

1. Precision measurement.
2. National measurement systems.
3. Industrial standardization.
4. Quality control.

We at K-SRI will be grateful to have your advice as to prospective candidates and topics for our session.

Dr. Jung:

Let me try to summarize our discussion session:

1. In advanced and advancing industrial societies, high precision and accuracy of the measurement standards system amount to indispensable necessity.

Some typical examples of benefits are:

a. In the dairy industry in Australia, the measurement standards system contributed to the expansion of the export of cheese and butter.

b. Color television in New Zealand would have failed without the high level of the measurement standards system.

c. Mica production in India is estimated to have benefited by value added to the mica products by a factor of 100 through precision of the measurement technology.

2. The production of satellites and propulsion rockets by Hughes Aircraft Company demonstrated that the depth of understanding by the industry of the importance of the national measurement system, that is traceable to the international standards, is a direct measure of the level of the technological sophistication and export capability of the firms and the country as a whole.

3. The responsibility of a national central research organization like K-SRI is not only to support the immediate needs for the improvement of the technical quality of the existing industries, but also to

do research to prepare for future needs and to provide leadership to the progressive development of industrial technology.

The emphasis is shifting from quality control (zero defect) in the production process toward the quality and performance assurance (zero failure) of the end products. To assure the adoption, modification, and continuous improvement of transferred (or transplanted) technology, we must learn the "know-why" in addition to the "know-how" to apply that technology. In addition to measurement research on dimensional and physical metrology, there are the other new tasks, investigations on the reliability and material characteristics, and the measurements of useable life span. The recent reorganization of NBS to create the National Engineering Laboratory seems to reflect this trend.

4. To approach the immediate problems of enhancing the level of the industrial technology, a country needs:

a. A vigorous government policy support for the establishment and development of the National Central Laboratory for the national measurement standards.

b. The establishment and strengthening of the National Standards Network System for the effective uniform dissemination of the measurement standards and measurement technology. Examples of such action are:

(1) In the U.S.A., National Conference of Standards Laboratories (NCSL).

(2) In Australia, the National Association of Testing Authorities (NATA).

(3) In New Zealand, the Testing Laboratory Registration Council (TELARC).

c. Vigorous financial and technical support for the growth of the instrument industries, all of which will be in the small and medium industry categories.

d. Organized systematic education and training systems for measurement manpower.

Prior to this Regional Seminar, there have been at least four similar international meetings.

a. ISMET in Tokyo, Japan,
b. BIPM Meetings in Paris, France.
c. Annual NBS/AID Workshops in Washington, DC, U.S.A.
d. IMEKO Conference in the USSR.

Each meeting had specific themes of its own. Nevertheless, the trend clearly indicates the increasing importance of international cooperation and collaboration in the metrology area.

It is hoped that future technical seminars in the Southeast Asian and Pacific countries will tackle specific problems for metrology in each country and that the linkages for mutual cooperation will be tightened by regular periodic contacts.

Let me close by thanking sincerely the discussion leaders and rapporteurs.

# CONCLUDING SESSION

## C.1 CLOSING REMARKS

Dr. Jong-Wan Choi
Industrial Advancement Administration
Seoul, Korea

I am sorry that I could not be with you at yesterday's session because the National Assembly is in session to discuss next year's budget. However, I heard that the sessions were most successfully carried out. I congratulate all of you for your excellent work and the achievements in the seminar. The discussion session today showed effective international cooperation in metrology by exchange of ideas and sharing valuable experiences.

I am confident that, with this spirit and continued cooperation between all of us in the region, we will enjoy a brighter future in metrology and standards.

As I have mentioned earlier, our Government will do its best in promoting sound metrology standards. There will be a campaign for metrology, parallel and in harmony with our quality control movement which has already been started. These programs are needed in modernizing our industries and for improving the quality of our industrial products. K-SRI will be in the front line in giving the technical guidance to these efforts, which our Government is directing and supporting.

You have come from all parts of the Asian and Pacific Region to learn from each other by introducing your own national experiences and comparing yours with others. As in my own country, each of you in your country has a tremendously important task in educating technical manpower and the general public. I wish each of you good luck in doing this. I have met many of you on various other occasions. I hope to see you again soon at a similar seminar. I believe somehow we should meet more often.

I would like to congratulate K-SRI for the excellent preparation and arrangements and to thank the U.S. NBS and AID for their support for this seminar. I wish you a pleasant tour and safe return home.

## C.2 CLOSING REMARKS

Mr. Robert S. Walleigh
National Bureau of Standards
Washington, DC

I am pleased to add my congratulations to Dr. Kim, Zae-Quan and to his staff for this Regional Seminar which must be considered a great success when measured by any standard. I also extend my thanks for the hospitality and many other expressions of interest and concern, which you have shown to your guests from abroad.

I congratulate the distinguished participants for their thoughtful and forthright papers which have shown similarity in, differences between, and problems of the measurement standards programs of the several nations here represented.

I wish to thank the rapporteurs who have been faithfully taking notes to summarize and paraphrase the discussions. On behalf of all of us, I extend thanks to Dr. C. Rhee and his organizing committee, and I wish to take special note of the efforts of Mr. K. S. Choi for all that he has done to make us comfortable in lodgings, food, transportation, sightseeing, etc., at all times.

I have noted that the questions from the audience on one or two occasions indicated a concern over the need and lack of understanding for a metrology standards program. I know that we have been discussing such subjects as, "Who is aware of the national capability for standards?" or "Does anybody out there need us?" I know that you have heard it said that Government sometimes has to be a leader in pointing out the needs for and benefits from standards. But you have also heard the benefits which can be derived once the programs begin to move forward in industry.

So I say to those of you who are on the staff of K-SRI, do not dwell on what may have sounded to you like negative prospects pertaining to metrology standards programs. From my own personal observations, I can say that I have been at NBS for 35 years and for 25 years in one of the top management positions. Seldom a year has gone by within my memory that there have not been discussions in the Director's office in which we have asked ourselves why we are not better recognized, or why we don't get money for all our programs. Such self-inspection is necessary, but it must be placed in proper perspective. Thus, although conditions are never ideal in any program when we look at ourselves as organizations, things look pretty good in general. We all come from organizations which enjoy a large measure of respect.

In summary, therefore, I can say with assurance that K-SRI has a bright future in their great and rapidly industrializing nation. Look

forward with confidence. You have an excellent facility and a very able staff. The future is yours.

## C.3 CLOSING REMARKS

Mr. Edwin A. Gales
U.S. Agency for International Development
Seoul, Korea

There are advantages and disadvantages of being one of the last speakers on the agenda. The advantage of the position of the last speakers is that no one can follow you to contradict or challenge your statements. The disadvantage is that everyone is a bit tired now, a bit hungry for lunch, and they want the speaker to get on with his talk. Therefore, I want briefly to add my congratulations to the Korea Standards Research Institute and its staff for the very obvious and apparent excellent planning that went into this conference; the National Bureau of Standards for their strong support; to the IAA and the Korean Government; and especially to the participants from the other countries who have shared their experiences, successes, and problems with us. We have a lot to learn from each other, and I look upon this conference as not the end of a dialogue, but the beginning of a dialogue that will lead to future contacts, correspondence, and mutual support among you, sharpening the tools of metrology and improving the products produced by your nations. AID is proud to take part in this project. Thank you.

## C.4 CLOSING REMARKS

Dr. A. Ghani
Pakistan Council of Scientific and Industrial Research
Karachi, Pakistan

On behalf of the seminar participants, I have been given the unique honor and privilege to place on record my sincerest thanks for the unprecedented hospitality that we are enjoying in this country. I also extend my warm congratulations for the success of this Regional Seminar to Dr. Zae-Quan Kim, as Chairman of the Seminar, to the members of the program committee, to the chairman and the members of the organizing committee, to the interpreter/rapporteurs of the various seminar sessions, and all the members of K-SRI who have contributed directly or indirectly to the success of this seminar.

As a friend, however, I will be failing in my obligations if I hesitate to bring to your notice my suggestions for attaining better accuracies in the absolute perfection of arrangements for the next regional seminar toward which you have already started to think. In this seminar program it was recorded that I would be making one of the closing statements on behalf of the visitors, whereas you have in practice given us the status of VIP guests. The program thus conveyed wrong information, but I believe that sometimes wrong information has helped in history to achieve great results. The other day Dr. Verma was asking an American friend why the Russians did not plan to send a man to the moon. He did not know that it was the Russians who leaked wrong information to the Americans that there were women on the moon.

The people of the Republic of Korea, I believe, must realize that it is the first developing country in Asia, a genuine LDC by any standard, that has successfully reached the take-off stage for industrialization through the system of free enterprise. It is, therefore, most essential for Korean leaders to show their industrial and cultural achievements to foreign friends and VIP guests for their information and education.

In the end, I would specifically like to convey my sincerest thanks, on behalf of all of us, to Steffen Peiser who has been officially declared as 50 percent Korean. I am, however, happy that if this drift in him continues, he may also lose the remaining 50 percent to Indonesia, India, or Pakistan in the very near future.

Thank you.

## C.5 CLOSING REMARKS

Dr. Zae-Quan Kim
Korea Standards Research Institute
Dae Jeon, Korea

First of all, I would like to thank you all for having helped us successfully to complete this seminar. Since this is the first international meeting held at Daeduk Science Town, it means a great deal to K-SRI and its future. I mentioned this also in my opening address.

As you have noticed, the construction is still underway. So it will be a while before we can function normally with our laboratories fully established. Under the circumstances, I am afraid that you may have suffered inconvenience. In spite of any hardship you might have had on this trip, nothing could have prevented us from having stimulating discussions since you have brought us your extensive experiences and stimulating ideas.

I hope that each of you in turn gained, through our presentations and discussions, many valuable ideas and knowledge from other participants' experiences and insights. This is a great learning process for all of us with many practical benefits to take home. I have already mentioned to most of you informally the possibility of forming a regional body of metrology, and we have had a brief discussion on this issue in the final session this morning. I gathered generally favorable responses. Let us continue the discussion on this during the remaining time on the industrial tour.

Now, with the momentum we have jointly gathered at this time, our efforts toward a working national measurement system can really be facilitated. I can proudly say that the awareness of the importance of metrology standards you have helped us to promote yesterday will make our work a lot easier. You have witnessed our Government's increased support of our efforts, illustrated by our Minister's remarks.

In any case, whether it be another metrology conference or similar seminars that we plan to organize at K-SRI in the future, please come back and join us in continuing the discussions we have started today. I wish to express a very sincere gratitude to all of you, and especially to those who sponsored this event with us. Hoping that this seminar was an equally memorable and worthwhile trip to you, I say thank you and a formal goodbye at this time, although in fact I am happy to remain with you on your industrial tour starting after an inspection of our laboratories this afternoon.

## APPENDIX I

## SEMINAR COMMITTEE

| | |
|---|---|
| Seminar Chairman: | Dr. Zae-Quan Kim, President, Korea Standards Research Institute (K-SRI) |
| Program Committee: | Dr. Wun Jung, Vice President for Metrology, K-SRI |
| Organizing Committee: | |
| Chairman: | Dr. Choonghi Rhee, Head, Temperature Standards Division, K-SRI |
| Members: | Dr. Nak Sam Chung, Head, Electromagnetic Standards Laboratory, K-SRI |
| | Dr. Chul Koo Kim, Head, Force Standards Laboratory, K-SRI |
| | Dr. Jae Chang Lee, Head, Office of Industrial Standards Dissemination, K-SRI |
| | Dr. Jong Chul Park, Head, Thermoelectricity Standards Laboratory, K-SRI |
| | Mr. Ki Sang Choi, Chief, Office of International Cooperation, K-SRI |

APPENDIX II

SEMINAR PROGRAM

Wednesday, September 27

SESSION I

1030 - 1200

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|---|---|
| Topic: | Quantitative Measurement Is the Basis for All Science and Technology |
| Chairmen: | Dr. N. S. Chung (Korea)<br>Mr. M. C. Probine (New Zealand) |
| Rapporteur: | Dr. J. C. Lee (Korea) |
| | Quantitative Measurement, the Basis for All Science and Technology - Mr. H. Steffen Peiser (U.S.A.) |
| | Importance of National Capability in Metrology for Industrial Development--the Indian Experience - Dr. A. R. Verma (India) |
| | Quantitative Measurement as a Basic Framework of Science and Technology - Dr. Seiji Takata (Japan) |
| | The Need for Quantitative Measurement in Hong Kong - Mr. Hung-kwan Lam (Hong Kong) |

1200 - 1300 Luncheon

SESSION II

1330 - 1510

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|---|---|
| Topic: | A National Capability in Metrology Is Essential to Industrial Development |
| Chairmen: | Dr. C. Rhee (Korea)<br>Dr. A. R. Verma (India) |
| Rapporteur: | Dr. C. K. Kim (Korea) |
| | National Measurement Capabilities for Industrial Development in Korea - Dr. J. W. Choi (Korea) |

Development of Metrology Capability in Step with Industry Needs—A New Zealand Experience - Dr. M. C. Probine (New Zealand)

Implementing Metrology for Developing Industrialization - Mr. Herudi Kartowisastro (Indonesia)

Assessment of the Requirements of Industries/Institutions for Services in the Field of Standards - Dr. A. Ghani (Pakistan)

The Importance of Metrology to Industrial Development - Mr. Mohd. Zin b. Hashim (Malaysia)

1510 - 1520 Coffee Break

## SESSION III

1520 - 1700

Topic: Measurement Is Needed to Select Raw Materials, Control Production and Assure Quality of Products

Chairmen: Dr. J. C. Park (Korea)
Dr. S. Takata (Japan)

Rapporteur: Dr. J. C. Lee (Korea)

NML and the Australian Manufacturing Industry - Dr. W. R. Blevin (Australia)

Status of Measurement Standards in Korea - Dr. Wun Jung (Korea)

But Is Industry Aware of Its Dependence on Metrology? - Mr. H. L. K. Goonetilleke (Sri Lanka)

The National Metrology and Calibration Service for Industry - Dr. Charoen Vashrangsi (Thailand)

1700 - 1800 Reception
(Hosted by Dr. J. W. Choi, IAA Administrator, Ministry of Commerce and Industry)

Thursday, September 28

## CONCLUDING SESSION

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|---|---|
| Chairmen: | Dr. Wun Jung (Korea)<br>Mr. H. Steffen Peiser (U.S.A.) |
| 0900 - 1000 | Discussion of Session I<br>Are We Aware of the Need for Metrology? |
| Leader: | Dr. Charoen Vashrangsi (Thailand) |
| Rapporteurs: | Dr. N. S. Chung (Korea)<br>Mr. H. Steffen Peiser (U.S.A.) |
| 1000 - 1100 | Discussion of Session II<br>But Is Industry Aware of Its Dependence on Metrology? |
| Leader: | Dr. M. C. Probine (New Zealand) |
| Rapporteurs: | Dr. C. Rhee (Korea)<br>Dr. C. K. Kim (Korea) |
| 1100 - 1200 | Discussion of Session III<br>Who Is Aware That a National Capability in Metrology Is Essential to Industrial Development? |
| Leader: | Dr. W. R. Blevin (Australia) |
| Rapporteurs: | Dr. J. C. Park (Korea)<br>Mr. R. S. Walleigh (U.S.A.) |
| 1200 - 1230 | Brief Closing Statements |
| | Dr. Jong Wan Choi (Industrial Advancement Administration)<br>Mr. R. S. Walleigh (National Bureau of Standards)<br>Mr. E. Gales (Agency for International Development)<br>Dr. A. Ghani (Visitors)<br>Dr. Z. Q. Kim (Korea Standards Research Institute) |
| Rapporteur: | Dr. J. C. Lee (Korea) |

## INDUSTRIAL TOUR

Thursday, September 28

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|---|---|
| Night | Kyungju City |

Friday, September 29

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|---|---|
| Visit | Hyundai Shipbuilding and Motor Companies |
| Night | Pusan |

Saturday, September 30

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| Visit | Pusan Machinery Technical Institute |
| Visit | Changwon Industrial Complex |
| Night | Seoul |

Sunday, October 1

Departure from Seoul

APPENDIX III

## LIST OF PARTICIPANTS

### A. Participants from Abroad

| | |
|---|---|
| W. R. Blevin (Dr.) | Chief Research Scientist, National Measurement Laboratory, Australia |
| Reinhart Czetto (Dr.-Ing.) | Institut fur Poduktionstechnik und Automatisierung (Institute for Production Technology and Automation), West Germany |
| Edwin A. Gales | Chief, Office of Development Loans, USAID/Korea |
| A. Ghani (Dr.) | Chairman, Pakistan Council of Scientific and Industrial Research, Pakistan |
| H. L. K. Goonetilleke | Deputy Warden of Standards, Price Control Department, Weights and Measures Division, Sri Lanka |
| Mohd. Zin b. Hashim | Standards and Industrial Research Institute, Malaysia |
| Herudi Kartowisastro | Director, National Institute for Instrumentation, Indonesian Institute of Sciences, Indonesia |
| Paul M. Kuhns | Program Development Manager, Hughes Aircraft Company, U.S.A. |
| H. Kunzmann (Dr.-Ing.) | Director and Professor, Physikalisch-Technische Bundesanstalt (PTB), West Germany |
| Hung-kwan Lam | Scientific Officer, Royal Observatory, Hong Kong |
| Joseph Larkins | H.Q. Joint U.S. Military Assistance Group-Korea, Gary Hodge, 8th Army |
| H. L. Maggs | Resident Representative UNDP/Korea |
| Hyrossi Okuno | Asia Parliamentary Council |
| William E. Paupe | Representative USAID/Korea |

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|---|---|
| H. Steffen Peiser | Chief, Office of International Relations, National Bureau of Standards, U.S.A. |
| M. C. Probine (Dr.) | Assistant Director-General, Department of Scientific and Industrial Research, Physics and Engineering Laboratory, New Zealand |
| Antonio L. Ramirez | Consul General, Republic of the Philippines, Seoul, Korea |
| Segundo V. Roxas | Deputy Minister, National Science Development Board, Philippines |
| Y. Sakurai (Dr.) | Director, National Research Laboratory of Metrology, Japan |
| Seiji Takata (Dr.) | Chief, 2nd Division of National Research Laboratory of Metrology, Japan |
| Charoen Vashrangsi (Dr.) | Director, Physics and Engineering Division, Department of Science, Ministry of Industry, Thailand |
| A. R. Verma | Director, National Physical Laboratory, India |
| Robert S. Walleigh | Senior Adviser for Office of International Affairs, National Bureau of Standards, U.S.A. |
| Erlinda Wight | K-SRI |
| Leon Wight | Controller, USAID/Korea |

B. Participants from Other Korean Organizations

| | |
|---|---|
| Jong-Wan Choi (Dr.) | Administrator, Industrial Advancement Administration (IAA) |
| Kwang-Duk Lee | Deputy Administrator, IAA |
| Hong-Ki Bai | Chief of Weights and Measures Division, IAA |
| Soon-Woo Hong | Information and Cultural Agency, American Embassy in Korea |
| Sang-Ho Doh (Lt. Col.) | Ministry of National Defense |

| | |
|---|---|
| Jong-Moo Byeon (Lt. Col.) | Ministry of National Defense |
| Eui-Suh Lee (Lt. Col.) | Headquarters, Republic of Korea (ROK) Navy |
| Soo-Yong Lee (Lt. Col.) | Bureau of Logistics, Ministry of National Defense |
| Duk-Kyu Yun | Director, National Industrial Research Institute |
| Byung-Chil Lee | Vice President, Industrial Site Development Corporation (ICDC) |
| Yu-Suk Jun | Director for Development, ICDC |
| Wun-Tai Kim (Lt. Col.) | ROK Navy Calibration Center |
| Chang-Won Lee (Capt.) | ROK Navy Calibration Center |
| Jung-Seok Won | Jeon-Nam Provincial Industrial Products Testing Center |
| Jae-Yeon Kim | Vice Governor of Choong Chung Nam Do |
| Bo-Hyun Park | Head, Chung-Nam Provincial Industrial Products Testing Center |
| Baik-Soo Kim | Head, Jeon-Buk Provincial Industrial Products Testing Center |
| Young-Yeon Choi | Head, Chung-Buk Provincial Industrial Products Testing Center |
| Young-Woong Kang | Fine Instrument Center |
| Sang-Koo Chang | Bureau of Atomic Energy, Ministry of Science and Technology |
| Young-Zae Park | Korea Institute of Energy Conservation |
| Chul Lee (Dr.) | Korea Nuclear Fuel Development Institute |
| Won-Koo Park (Dr.) | Korea Nuclear Fuel Development Institute |
| In-Seol Suh | Korea Nuclear Fuel Development Institute |
| Sun-Hui Cho (Dr.) | Korea Institute of Machinery and Metals |
| Jong-Chul Cho | Korea Institute of Machinery and Metals |

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|---|---|
| Dai-Kyu Choi | Korea Institute of Machinery and Metals |
| Keuk-Chun Kim (Dr.) | President, Korea Research Institute of Shipbuilding |
| Tai-Sub Kim | Vice President, Korea Research Institute of Shipbuilding |
| Chi-Rang Choi | Korea Research Institute of Shipbuilding |
| Young-Sub Yun | Korea Research Institute of Shipbuilding |
| Chwa-Kyung Sung (Dr.) | President, Korea Research Institute of Chemical Technology |
| Jong-Ok Lee | Korea Research Institute of Chemical Technology |
| Sik-Moon Bahn | Korea Research Institute of Chemical Technology |
| Jong-Hwan Kim | Korea Research Institute of Chemical Technology |
| Jong-Ho Kim | Korea Research Institute of Chemical Technology |
| Do-Soon Park | Korea Research Institute of Chemical Technology |
| Haeng-Nam Baik | Korea Research Institute of Chemical Technology |
| Su-Bong Lee | Korea Research Institute of Chemical Technology |
| Roh-Hak Park | Korea Research Institute of Chemical Technology |
| Jung-Dai Kim | Ssang-Yong Central Research Institute |
| Ryong Choi | Ssang-Yong Central Research Institute |
| Sung-Soo Choi | Ssang-Yong Central Research Institute |
| Gap-Soo Noh | Ssang-Yong Central Research Institute |
| Tai-Chun Kim | Ssang-Yong Central Research Institute |
| Bae-Duk Yang | Agency for Defense Development |

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|---|---|
| Yang-Bok Chai (Dr.) | Korea Institute of Science and Technology |
| Woong-Ki Kang (Dr.) | President, Korea Research Institute of Energy Conservation |
| Hyun-Duk Lee (Dr.) | Korean Atomic Energy Research Institute |
| Sung-Jae You (Dr.) | Korean Scientific and Technical Information Center |
| Soon-Dal Choi (Dr.) | President, Gold Star Central Research Institute |
| Soo-Young Kim (Dr.) | President, Korean Institute of Metals |
| Dong-Hoon Kim (Dr.) | Korean Institute of Metals |
| Myong-Won Suhr (Dr.) | President, Chung-Nam University |
| Ki-Suk Maeng | Professor, Chung-Nam University |
| Hee-Pill Oh (Dr.) | Professor, Chung-Nam University |
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A regional seminar sponsored by the Korea Standards Research Institute, the National Bureau of Standards, and the U.S. Agency for International Development was held at the new K-SRI Laboratories at Daeduk near Dae Jeon in the Republic of Korea on September 27-28, 1978. The participants representing most of the countries in the South Asian and Western Pacific Region discussed the importance of providing services in measurement science and technology (metrology) to governmental and industrial organizations in the region. The consensus was that a need for a central national capability in metrology existed in countries at all levels of development, and that that central organization could be a focal point for intra- and international cooperation, which alone could lead to compatibility of measurements, a prerequisite for quality control for all kinds of products in domestic and international markets. Australia and New Zealand had established a group of accredited test laboratories to disseminate the accuracies inherent in the national measurement system. Industry was increasingly aware that metrology was essential to development, but the specific needs at appropriate accuracies needed to be established by surveys. The Korean Government strongly supported the establishment of metrological services as is well illustrated by the new K-SRI laboratories.

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